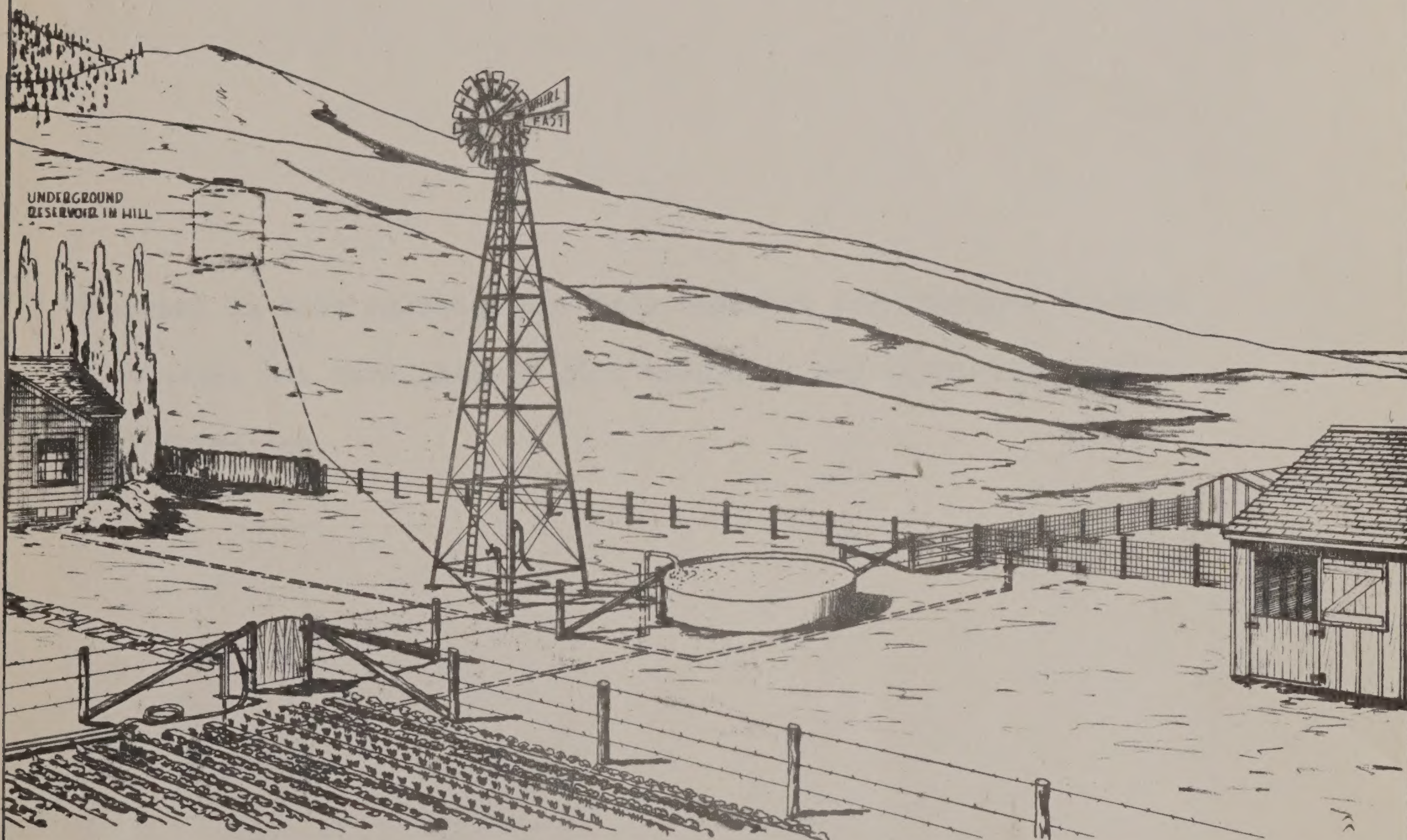
FARMSTEAD WATER SUPPLY MANUAL



UNITED STATES DEPARTMENT OF AGRICULTURE FARM SECURITY ADMINISTRATION

OFFICE OF CHIEF ENGINEER
WATER FACILITIES PROGRAM

DISTRICT VII·
REGION X·
DENVER, COLORADO
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-Moore-

Material in this handbook has been compiled from various sources. No attempt has been made to give credit to any particular origin of information.

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FARMSTEAD WATER SUPPLY MANUAL

I INTRODUCTION

The purpose of this Handbook is to make available to field men some of the general principles that must be taken into consideration in the development of water for domestic and livestock purposes.

It is beyond the scope of this manual to present detailed plans and specifications covering every problem that might be encountered. However, it is hoped that by making use of the data contained herein, necessary changes may be made to fit individual cases, and thus insure a water supply that is pure, dependable and adequate.

Purity of Supply

Water for domestic use must be pure. Pure water cannot always be determined by appearance and taste. Good water is clear, odorless, colorless, somewhat soft, and neither strongly acid nor alkaline. Where possible, a test of the water should be made before undertaking development. Such tests usually will be made by County or State Health Authorities if samples of the water are submitted to them. After a development has been put into use, periodic tests should be made of the water for impurities. A water supply should not be located where there is liability of contamination from barnyards, stock lots, outdoor toilets and cesspools.

Dependability of Supply

Every effort should be made to determine the dependability and availability of the water supply before development is undertaken. This can be accomplished in one of the following manners:

a. Investigate existing supplies in proximity to the site as regards depth of hole, quality and quantity of water, pumping head, and well log.

b. Obtain information from local well drillers about wells drilled in the community.

c. Consult a geologist if there is any question regarding the availability of water.

d. Where a spring development is contemplated, determine if possible the supply of water available during periods of drouth.

Adequacy of Supply

The following table sets forth water requirements that are considered to be a safe basis on which to estimate the total daily consumption of water in Montana, Wyoming and Colorado:

	Average Gallons Per Day
For each member of a family for all uses.................	35
Schools, per person..	7
For each horse, mule, or head of cattle.................	15
For each dairy cow...	30 to 40
For each sheep or goat.....................................	1 to 2
For each mature hog..	2 to 3
For each shoat...	1.5
For each 100 chickens......................................	3
For each 100 turkeys.......................................	7
For each 100 square feet of garden.........................	165*
To sprinkle 100 square feet of lawn ($\frac{1}{4}$ inch of water)...	16 gallons
To soak 100 square feet of lawn (1 inch of water).......	64 gallons

* The estimate for a garden is based on the requirement of eight inches of water per month for the months of June, July and August. Since this constitutes an extended period, the well must be designed to supply the daily requirements unless an excessively large storage is available.

II SPRINGS

Source of Supply

Springs are the natural emergence of ground waters that find their way to the surface through crevices or porous earth strata. They are of all gradations between concentrated outflows emerging from the ground at a single point or within a restricted area, which are characteristic of true springs, and the diffused emergence of water over large areas, which is characteristic of general seepage.

Contamination

Before developing a spring for domestic purposes, a survey should be made of all existing or proposed buildings, sewage disposal works, drainage, and any other conditions which may affect the water supply.

Development

To develop a spring, it is necessary to clean out the opening,

locate the true water-bearing outcrop, and provide means for collecting and utilizing the outflow. The spring should be protected from surface damage, and suitable cribbing and collecting facilities should be provided to keep the collection sump and inflow channels open. Since the flow of a spring is dependent on the head of water, any attempt to raise the outlet in order to gain elevation may result in a decreased yield, or even cause the spring to change its course and emerge at some other point.

It is often difficult to determine the most suitable form of spring development until some excavating has been done and an investigation made. Before undertaking an extensive development, it may be advisable to make numerous test borings in the immediate vicinity of the spring to determine the approximate water table profile and the extent and direction of movement of the water. A study of the relative heights to which water rises in a group of test holes will make it possible to plan a better collection system.

Springs satisfactory for household use generally emerge from hillsides, and the inflow is in a downward or horizontal direction. The water percolates from passages or numerous small openings in the permeable material, which overlays a less pervious stratum. The discharge may be restricted to one point or to a limited area, or it may extend a considerable distance across the slope. A suitable development must intercept the flow and collect it at some central point. Vertical excavation or borings through the impervious stratum may result in complete or partial loss of spring flow.

A V-shaped collecting wall with the ends extending back into the hillside to divert the water to a central point at the apex is often used. See Figure 1 for details. A concrete collecting wall is preferable, and it should be at least six inches thick, with the ends extending far enough back into the hillside to prevent outcropping water from going around them. The wall should extend one or two feet above ground level, and should be carried deep enough to reach a good foundation and prevent underseepage. A box encasement with removable cover may be constructed in the apex of the V-shaped wall to make inspection and cleaning easy. The upper side of the box must be made pervious, and a generous amount of clean sand, gravel and rock should be filled in behind the spring box and collecting wall to facilitate the passage of water. The porous material should then be covered with soil of a depth sufficient to completely bury the wall and prevent the entrance of snakes, frogs, or vermin. Where spring water emerges at several widely spaced points, coarse gravel and rock filled

ditches, or preferably, open-jointed tile embedded in gravel-filled ditches can be used to advantage for collecting water from outlying points, and thus the expense of extending collecting walls long distances into or along the hillside is eliminated.

All springs should be protected from surface run-off by a suitable diversion ditch, and they should be enclosed by a substantial fence to exclude livestock.

III CISTERNS

Types

Brick, concrete, and cement plaster are the most common materials used for the construction of cisterns.

The soil in some areas is of such nature that a reasonably durable cistern can be made by plastering directly on the earth wall. This type of cistern can be constructed without the use of forms and with less material, but it is not as strong and durable as the brick or concrete cistern. The walls are thinner and crack easier, and unless the cistern is constructed in a good, firm, well drained soil, the results secured are likely to be disappointing. The cement-plaster cistern should always be circular in shape.

Brick cisterns are satisfactory and can be constructed without the use of forms, but skilled labor for laying the brick is desirable. They are usually circular in shape with a jug-shaped neck. The shoulders of the neck are formed by drawing in each layer of brick as the neck is built up. It is necessary to plaster the inside of this type of cistern with a thick, rich cement mortar to make it water-tight. The outside of the jug neck should also be plastered to a sufficient depth to cut off outside seepage.

In some localities concrete is becoming the most popular material used for the construction of cisterns. Concrete cisterns may be square, rectangular, or round. Square or rectangular cisterns have several disadvantages that more than offset their apparent ease of forming:

1. Thicker walls and more reinforcing are required in order to give the necessary strength.

2. This type of cistern is subject to cracking at the corners.

3. More material is required in the top and bottom than in a round one of the same capacity.

4. More form lumber is required.

5. They are harder to keep clean than round cisterns.

However, if it is desired to build a cistern of this type, plans will be supplied by the office of the District Engineer. When requesting these plans, give the required capacity of the cistern and the type of soil in which it is to be constructed.

Round cisterns may be constructed with six-inch walls and with little reinforcing. Practically all the cisterns that will be installed in any locality will be the same diameter and vary only in depth. One set of forms, if properly constructed, can be used for all the cisterns in the community. A number of farmers can club together and divide the expenses of constructing the forms, or the first one to install a cistern can build the forms and rent them to others in the community. In other cases, satisfactory arrangements can be made with a local lumber dealer to construct the forms and rent them to farmers who wish to use them. In this way the most satisfactory type of cistern can be secured, and the use of a collapsible form in a community will not only simplify the work, but will also greatly reduce the cost and labor requirements for each installation.

When excavating for a round cistern, smooth, uniform walls can be obtained by the use of a scribe similar to that shown in Figure 2. To use this scribe, a vertical pipe is sunk in the center of the proposed cistern to the desired depth of excavation. The arm of the scribe is then rotated around the pipe as an axis.

Figures 2 and 3 show typical cistern designs. Table 1 shows capacities of cisterns, and Table 2 shows approximate amounts of materials required.

The details of the construction of forms for circular cisterns are shown in Figure 4. The form is constructed in six segments that are fastened together with bolts. After the concrete sets, the removal of the wedges provides ample clearance so that the form can easily be moved up or completely removed from the cistern. The form itself is three feet high, and the cistern is constructed in rings; the floor and first ring are installed first, then the form is moved up for the next ring. This is continued until the cistern is completed. Concrete should set at least 24 hours, or longer if necessary, before the forms are moved. The top of each ring should be thoroughly cleaned with a wire brush, dampened and covered with mortar prior to placing fresh concrete. If extreme care is not used in making these joints, leaks will develop when the cistern is filled. The wire mesh reinforcement

must remain in proper position in order to be effective.

To construct the top of the cistern a platform is built level with the top of the sidewall, and the inside form for the throat is put in position. After placing two inches of concrete on this platform, the previously prepared grid of reinforcing steel is laid, the outside throat form is placed, and the pouring operations continued to completion. Details of construction are contained in Table 2 and Figure 3.

When the concrete has cured sufficiently, the throat forms and false platform can be removed from the cistern. The cover is made on a separate floor or platform which is not shown. All of the forms should be thoroughly oiled with linseed oil before they are used. This not only prevents the wood from absorbing moisture from the concrete but also allows the forms to be removed more easily.

All concrete used in the construction of cisterns should be watertight. The appendix contains detailed instructions for the mixing and placing of concrete.

Aeration

Sometimes water in cisterns will acquire an offensive odor due to lack of air. This condition can be remedied by pumping the water out and letting it fall back into the cistern through the filler pipe.

TABLE 1
NUMBER OF GALLONS IN ROUND CISTERNS AND TANKS

Depth in Feet	Diameter in Feet							
	5	6	7	8	9	10	11	12
2	294	423	576	752	952	1175	1422	1692
3	441	634	864	1128	1428	1762	2133	2538
4	587	846	1151	1504	1903	2350	2843	3384
5	734	1057	1439	1880	2379	2937	3554	4230
6	881	1269	1727	2256	2855	3525	4265	5076
7	1028	1480	2015	2632	3331	4113	4976	5922
8	1175	1692	2304	3008	3807	4700	5687	6768
9	1322	1904	2591	3384	4283	5288	6398	7614
10	1469	2115	2879	3760	4759	5875	7109	8460

TABLE 2

CONCRETE, CEMENT, AND REINFORCEMENT REQUIRED FOR ROUND CISTERNS

Diameter in Feet	Walls Per Foot Depth	Top	Bottom	Material
5	8.6 c.f. 2.0 sks. 18 ft.	26.5 c.f. 6.1 sks. 80 ft.	14.1 c.f. 3.3 sks.	Concrete Cement Reinforcing Mesh ½"Ø Reinforcing Steel
6	10.2 c.f. 2.4 sks. 21 ft.	31.0 c.f. 7.2 sks. 120 ft.	19.2 c.f. 4.5 sks.	Concrete Cement Reinforcing Mesh ½"Ø Reinforcing Steel
7	11.8 c.f. 2.7 sks. 24 ft.	38.2 c.f. 8.9 sks. 170 ft.	25.1 c.f. 5.8 sks.	Concrete Cement Reinforcing Mesh ½"Ø Reinforcing Steel
8	13.4 c.f. 3.1 sks. 27 ft.	47.3 c.f. 11.0 sks. 240 ft.	31.8 c.f. 7.4 sks.	Concrete Cement Reinforcing Mesh ½"Ø Reinforcing Steel
9	14.9 c.f. 3.5 sks. 30 ft.	53.3 c.f. 13.5 sks. 340 ft.	39.3 c.f. 9.1 sks.	Concrete Cement Reinforcing Mesh ½"Ø Reinforcing Steel
10	16.5 c.f. 3.8 sks. 33 ft.	71.5 c.f. 16.6 sks. 450 ft.	47.5 c.f. 11.0 sks.	Concrete Cement Reinforcing Mesh ½"Ø Reinforcing Steel
11	18.1 c.f. 4.2 sks. 37 ft.	87.2 c.f. 20.2 sks. 570 ft.	56.6 c.f. 13.1 sks.	Concrete Cement Reinforcing Mesh ½"Ø Reinforcing Steel
12	19.6 c.f. 4.6 sks. 40 ft.	99.9 c.f. 23.1 sks. 710 ft.	66.4 c.f. 15.4 sks.	Concrete Cement Reinforcing Mesh ½"Ø Reinforcing Steel

An example is given to show the use of the table:

Example -

Find the materials required for a cistern with an inside diameter of 10 feet and an inside height of 10 feet.

Solution -

From inspection of Table 2, the walls require 16.5 cubic feet of concrete, 3.8 sacks of cement, and 33 feet of reinforcing

mesh per foot of height. Since the cistern is 10 feet high, these quantities must be multiplied by 10 and added to the top and bottom materials to obtain the total amounts:

165 + 71.5 + 47.5 = 284	cubic feet of concrete
38 + 16.6 + 11.0 = 65.6	sacks of cement
330 + 0 + 0 = 330	square feet of reinforcing mesh
0 + 450 + 0 = 450	linear feet of 1/2-inch round reinforcing steel

Filters

Some people think that the use of a filter will purify water and make it satisfactory for drinking or cooking purposes, and many people think that it is not necessary to clean a cistern when a filter is used. Both of these impressions are false, especially the former. The filter removes suspended matter or sediment from the water, but it does not remove dissolved minerals or bacterial contamination.

When a filter is properly constructed and operated, it will do a great deal to assist in keeping the water clean, but it should not be relied upon entirely. Even though the filter is used, it is advisable to empty the cistern occasionally when the water is low and give it a thorough cleaning and airing.

The filter should be cleaned by removing the layer of clogged filtering material and replacing with clean fresh sand.

A recommended type of sand filter is shown in Figure 2.

IV WELLS

Location

A well should be located so that it will be reasonably accessible for cleaning, repairs, tests, inspection and treatment.

The most essential data to be checked for obtaining the proper location of a well are:

1. Relative elevation with respect to flood conditions;

2. Direction of surface water runoff;

3. Probable direction of ground-water flow;

4. Possible sources of contamination, such as privies, cess-

pools, septic tanks, sewer lines, sink holes, abandoned wells, barns, stables, and polluted streams;

5. Availability of sufficient potable water at reasonable depths.

Types

In this region, wells for domestic and livestock purposes may be divided into the following types:

1. Dug and bored;

2. Driven;

3. Drilled.

Dug and Bored Wells

Dug and bored wells are generally shallow, and are defined as those which tap a water-bearing formation lying near the ground surface. The essential requirements necessary to obtain a safe supply of drinking water from dug or bored wells may be listed as follows:

1. Proper location with reference to any possible source of contamination;

2. Water-tight curbing or casing to a depth of at least ten feet below natural ground surface and to a greater depth when necessary to reach a firm, compact, and impervious stratum;

3. Curbing and casing to extend eight to twelve inches above natural ground surface and to be surrounded with well tamped earth, providing for good drainage of all water away from the well;

4. A well cover or pump slab of reinforced concrete, sealed to the top of the curbing in a water-tight manner. The surface of the slab should slope away from the pump.

5. The opening in the well cover or the pump slab for the pump should be large enough to admit the cylinder, and should be made with a wrought iron pipe sleeve sealed into the slab. The upper end of this sleeve should extend at least one inch above the surface of the slab.

6. Where manholes are provided in the well slab they should have overlapping covers which can be maintained watertight.

In some parts of the region, bored wells, ranging in diameter from six to twelve inches, are developed instead of wells of larger diameter. These wells are generally bored with an auger operated by hand and then cased with terra cotta pipe or standard well casing. Although this type of well is not recommended, it is possible to construct it so as to be reasonably safe from contamination. Wooden casing should never be used in domestic wells.

Figures 5 and 6 show examples of typical dug wells.

Driven Wells

Shallow tubular wells, called driven wells, are sunk in various ways, depending upon the size and depth of the well and the nature of material or strata encountered.

The two principal methods of sinking such wells are the "closed-end" method and the "open-end" method.

The Closed-End Method

In this type of construction the well tube consists of a wrought iron pipe from one to three inches in diameter, closed and pointed at one end, and perforated for some distance therefrom. The tube thus prepared is driven into the ground by a wooden maul or block until it penetrates the water-bearing stratum. The upper end is then connected to a pump, and the well is complete, with the exception of developing by pumping to clear the well of any sand. Where the water-bearing stratum is fine sand, the perforated portion generally is covered with brass gauze of a fineness depending upon the fineness of the sand. To prevent injuring the gauze and clogging the perforations in driving, the well point is usually made larger than the tube, or the gauze may be covered by a perforated jacket. Figure 7 shows details of the closed-end well and the common form of well point. This well is adapted for use in soft ground or sand and for depths not to exceed 25 feet.

Open-End Method

In hard ground, for the larger sizes (two to four inches), and for greater depths, the open-end method of construction has proved to be more satisfactory. This type of well is sunk by removing material from the interior and, at the same time, driving the tube.

The material is removed from the interior by means of a water jet. The water for jetting purposes should be of an approved quality. Where formations are known to be hard, or the well deep, a steel cutting edge or casing shoe may be screwed on the end of the tubing.

With this type of well the lower portion may be perforated where the water-bearing stratum is course or gravelly. If sand is encountered, the holes may be covered with brass gauze, or the tube may be sunk, and a strainer inserted. If a strainer is inserted, the tube should be withdrawn nearly to the top of the strainer, and a seal made just above where the strainer joins the lower part of the well tubing. This is generally done with a lead packer. It is always best to locate the strainer so that it will be entirely under water at all times. Figure 8 shows details of the open-end well.

Reconstruction of Existing Wells

Existing domestic wells which may be subject to contamination should be reconstructed and properly sealed. Dug wells with stone or brick curbing often can be rebuilt by encasing the existing curbing with concrete. A satisfactorily reconstructed well of this type is shown in Figure 9. In some instances the buried slab construction, as shown in Figure 10, is more desirable.

Often, in the case of dug wells, it becomes necessary to give an old well a thorough cleaning to remove all silt and foreign matter. Care must be exercised on entering wells that are deep and which have been closed for a period of years, as they may contain dangerous gases or a lack of oxygen which may asphyxiate a man before he has an opportunity to come out. Before any such well is entered, it should be opened for several hours, and then a lighted lantern should be lowered to the bottom. If the lantern continues to remain lighted, it should be reasonably safe to enter the well.

Where wells prove unsatisfactory and are abandoned, all reclaimable materials should be removed and the well hole plugged with concrete to prevent surface pollution reaching the underground strata through the hole. Under no conditions should an abandoned well be used for the disposal of sewage or other waste.

Drilled Wells

Where depths in excess of 75 to 100 feet are necessary, drilled wells are the most economical type. A satisfactory well is partly

based on the actual drilling, and the type of drilling to be employed can be best determined by contacting local drillers. For a well drilling contract, see Form FSA-498. The sanitary requirements of drilled wells are the same as for other wells.

The diameter of the well or casing is governed by the quantity of water required. Casing diameters will rarely be less than four inches or greater than eight inches. The hole should be straight, and extend well into or through the water-bearing sand.

A complete and accurate log of each well should be made recording the different types of soil as well as the depths (measured from normal ground elevation) at which same are encountered. The log also should further indicate the depth to water-bearing stratum and the distance into the stratum that the well is drilled. Exhibit A of Form FSA-498 may be used for this purpose.

The estimated cost per foot for drilling the well should include setting the casing and also the strainer if one is used.

It is desirable to drive the casing to solid rock, into solid clay, or some impervious stratum, and have it sufficiently seated and sealed to cut off all surface and undesirable ground water. This seal can be made by any of the following methods:

1. Setting the bottom of the casing on a shoulder in the well made by reducing the size of the drill hole and sealing the outside with grout as shown in Figure 11;

2. Driving the casing into clay, shale, or similar formations;

3. Lead packer;

4. Expanding rubber packer.

In some localities, it will be found that ground water conditions require the shutting-off of highly mineralized or salt water which may lie above the stratum to be developed. In this case it may be necessary to completely seal the casing throughout its entire length by grouting. The grouting of wells in this manner is recommended when there is any question as to proper and efficient sealing at the base of the casing pipe.

When grouting a well, best results are obtained by the use of neat cement and water in the ratio of one bag of fresh cement

(free from lumps), to five gallons of clean water. Hydrated lime to the extent of 10 per cent of the volume of cement may be added to make the grout mix more fluid and thereby facilitate placement by pumping equipment. Where the annular space is of sufficient size to assure proper sealing, cement grout consisting of equal parts of clean sand and fresh cement, using water as stated above, may be used. Grouting should be done in one continuous operation.

The top of the well should be sealed by means of a concrete slab as indicated in Figures 11, 12 and 13. The slab is made large enough to serve as a base for the pumping equipment. The casing should extend about two inches above and make a watertight connection with the base, which should be not less than six inches thick.

Casing

Wherever possible new casing should be used, as the life of the well is dependent on the life of the casing. Second hand casing is used only when the quality is equivalent to that of new pipe. The casing should be standard or extra heavy black wrought iron, galvanized wrought iron, or steel. Steel pipe should not be used where there is any possibility of such casing being attacked by elements in the soil or ground water. Steel casing in some instances has been found to corrode and rust out in a short time if not grouted its entire length.

All used oil well casing must be rigidly inspected before use, and must be in first-class condition, free from rust pits, and thoroughly steam cleaned to remove all oil and gas residue.

The use of sheet metal casing is not recommended except in areas where local conditions have proved it to be satisfactory. It does not have the life of standard casing, the joints are not tight enough to preclude seepage of undesirable water into the well, and it may collapse when used in unconsolidated material under an appreciable head. The casing should be set in accordance with the provisions contained in Form FSA-498.

If the casing is seated in clay or on non water-bearing rock, a screen or perforated section of casing should be used at the location of the aquifer to permit water to enter the well. The size and number of perforations are both important. Drilling samples should be taken, and size of perforations so chosen that about 60 per cent of the grains will pass through the openings. As the finer material is pumped out, the larger grains will settle around the casing, forming an area with greater porosity and larger passages for water flow. Pumping tests will indicate the

adequacy of perforations. If the water is obtained from fine sand, a sand screen may be required. This should be determined from the well log.

Testing and Developing Wells

Upon completion of a well which has been considered capable of yielding an adequate supply of clear, sand-free water, the well should have a pumping test of six hours or longer of continuous pumping. The pumping test should determine:

1. The quantity of water the well will yield within a given time;

2. The maximum drawdown;

3. The pumping or dynamic water level of the well;

4. The static water level.

The drawdown should be measured if possible from the static level or the level of the water before pumping begins, and may be checked at various stages during the pumping period. The yield at various depths of drawdown should be carefully and accurately measured by the use of weirs or other approved methods.

In some instances where the water-bearing formation is fine sand or a dense formation through which the flow is very slow, it is advantageous to "develop" the well after the water-bearing stratum has been reached. In such instances, the casing should be extended at least two feet into the water-bearing stratum and the well screen or strainer set in position with the bottom plugged. Then the casing should be withdrawn nearly to the top end of the strainer to which it should be properly swaged with a lead packer or by other approved methods. The well should then be developed by back-flowing, surging, pumping, and bailing until all fine sand in the sand stratum outside the strainer screen has been drawn into the well and bailed out, and clear water, free of sand is obtained.

V PUMPING EQUIPMENT

Satisfactory performance depends upon the selection of proper equipment for the specific working conditions. Inferior or worn-out pumping equipment is often the cause of contaminated wells and excessive operating costs.

The capacity of pumping plants should be sufficient to pump an amount

of water in eight hours equal to the maximum daily consumption. Therefore, the capacity in gallons per hour should be not less than 1/8 of the maximum daily consumption.

Drop Pipe

All drop pipe should be standard galvanized pipe. It is advisable to use a pipe having an internal diameter of the next standard size larger than the cylinder to permit removal of the valves for repair without pulling the drop pipe. The pipe should extend far enough into water so that the well may be pumped continously at its rated capacity without danger of exposing the suction stub.

The pipe must be suspended by some type of clamp. A clamp may be fabricated from 3/8-inch or 1/2-inch flat iron. However, a cast iron pipe holder with set screws is the most satisfactory method to hold pipe. A coupling, tee, or some other fitting should be screwed to the pipe just above the clamp so that the fitting rests on the clamp, and the weight of the pipe is then carried by the clamp. An asphaltic seal is recommended between the clamp and pipe, and clamp and casing.

Cylinder

The size of the cylinder is determined by the pumping rate, well depth, and size of wheel if a windmill is used. Always select a cylinder having a capacity somewhat less than that of the well to permit continuous pumping without danger of lowering the water to the point where the suction stub is exposed. The local dealers can supply data on the largest size cylinder to be used with a windmill installation.

In order to provide frost-proof installations, the cylinder should be placed below the frost line, and a weep hole placed in the drop pipe above the cylinder for draining the pump and upper portion of the pipe.

Pumps

There are two general types of pumps: suction and force. A suction pump has the cylinder above the water and does not raise water above the pump or discharge it under pressure. A force pump can raise water above its own elevation and against pressure. The practical lift of a suction pump varies from 22 feet at sea level to 15 feet at an elevation of 8,000 feet. So many designs and makes of pumps are available that it is impractical to advise what type should be used in each in-

dividual case; actual conditions and demands must be the controlling factors. Any reputable dealer can supply information for a specific installation.

The pumping equipment for all wells should be installed in such a manner that the entrance of contaminated materials into the well or water chambers of the pump will be prevented. The pumping outfit should be of standard make and of such design that repairs can be quickly made. Hand pumps should be of closed-top construction and adaptable for use with windmills or pump jacks as may be required. The closed top is desirable because it does not allow contamination to enter the pump. In deep well construction where power installations are used, the pumping equipment should not be supported on the casing. Typical pump installations are shown in the well figures.

Air-Lift Pumps

The air-lift pump is widely used for raising large amounts of water from exceptionally deep drilled wells. It is capable of raising a greater quantity of water from a small drilled hole than can be pumped by any other method. However, the efficiency of the air-lift pump is less than other types of deep well pumping equipment.

Where water is pumped by means of an air-lift system, the air compressor should be placed in a room as free as possible from dust, and at such an elevation that flooding will be impossible. The air from the compressor should be discharged into a storage tank so designed as to extract from the compressed air all oil or oil mist. In order to minimize the possibilities of oil contamination, the use of oil traps, filters, and as little oil as will provide satisfactory operation of the compressor is recommended.

The air intake of any air-lift system or mechanical aerating apparatus should be at least 6 feet above the floor surface if indoors, and 10 feet above the ground if outdoors. The air intake should be so constructed as to prevent the entrance of birds, insects, rain, snow, or other contaminating materials, and minimize the entrance of dust.

Hydraulic Rams

Hydraulic rams utilize the principle of water hammer, and can operate economically and with little maintenance. In instances where a spring must be used to supply water for a building that is located some distance away, a ram may be found practical.

Conditions for successful ram operations are as follows:

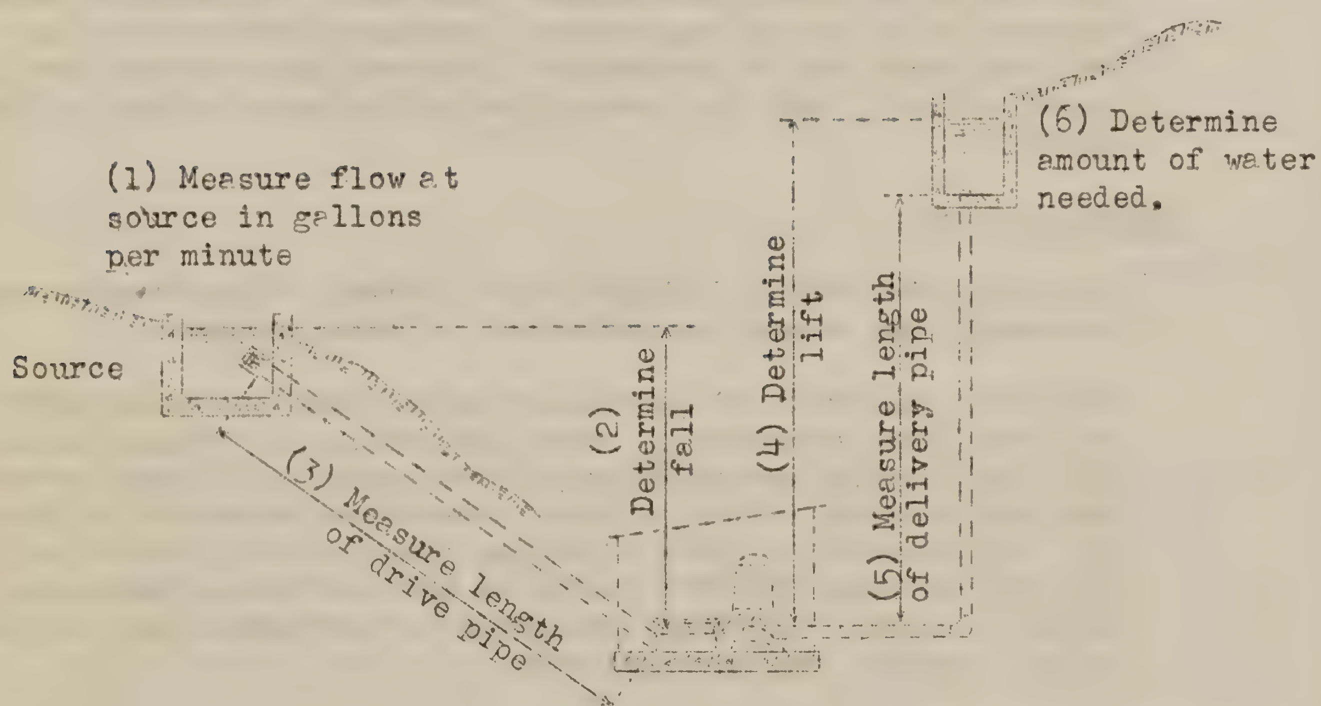
1. Not less than 18 inches fall (24 inches or more is preferable);

2. Not more than 30 feet fall (some manufacturers prefer that their rams operate on a maximum of 16 feet fall);

3. Not less than 25 nor more than 250 feet of drive pipe;

4. Flow of at least $1\frac{1}{2}$ gallons per minute.

Before a hydraulic ram is installed, certain necessary data should be secured as indicated in the following sketch:



HYDRAULIC RAM LAYOUT

There are many different types and sizes of rams, and it is important that all controlling factors be known before such equipment is purchased. The manufacturers of such equipment can furnish full details regarding the requirements of the respective sizes of rams, and their instructions must be closely followed to insure efficient results. A typical hydraulic ram installation is shown in Figure 14, together with some useful data as to the requirements and capacities for various installations.

Windmills

In selecting a proper windmill for any definite location, the prevailing wind velocity, the size of the wheel, the diameter of the cylinder, and the lift should be given special consideration to avoid overloading and to assure efficient operation. Windmill dealers can help in picking the appropriate size of windmill. Three times the actual daily water requirements should be used as a basis for determining wheel size to allow for calm periods when the mill will not operate. Windmill specifications are contained in the appendix.

It is advisable that windmills be equipped with an auxiliary hand pump for emergency purposes, and an automatic shut-off device should be installed wherever possible. In sections where extended calm periods are common, the installation of a pump jack and motor may be desirable. The pump jack should have all gears enclosed, and the stroke must be the same as that of the windmill.

Windmill Tower

Towers may be built of either wood or steel. When wooden towers are used, they should be protected by lightning rods.

The tower should be of sufficient height that the wheel will be ten feet above surrounding trees and buildings. Specifications for steel towers are contained in the appendix. Plans covering the construction details of wood towers are contained in Figure 15. The foundation posts of wooden towers should be set solidly. If cedar or other durable timber is not available, creosoted posts should be used. Platforms should be of sufficient size and rigidity to hold a man and equipment.

VI STORAGE TANKS

The elevation and location of storage tanks is a matter of great importance as it regulates the pressure of the water in the entire

distribution system. Proper elevation assures some fire protection which often can be obtained with very little additional expense if thought is given such matters in planning the proposed system.

The tank should have a storage capacity equal to five times the daily requirement when pumping with a windmill. When a pump jack and motor is installed, this capacity may be reduced to $1\frac{1}{2}$ or 2 times the daily water requirements. Capacities of round tanks are given in Table 1.

Exposed Tanks

Cypress or Redwood is preferable to steel as a material for exposed storage tanks. These woods are longer lived than steel, they are not susceptible to corrosion from minerals in the water, and due to the insulating effect of the wood, the water is less subject to temperature changes. A tight cover must be provided for sanitary reasons.

Dimensions for any capacity tank may be obtained from manufacturers. Manufacturers will also supply prints showing proper installation. Care must be taken when installing wooden tanks to see that the bottom of the tank rests firmly on the joists of the tower. No weight should be supported by the rim which extends below the bottom of the tank. Filler screeds or bottom supports of 2"x2" material may be placed so that the weight is carried by the tank bottom. These screeds should be about 12 inches apart and placed at right angles to the bottom staves.

In cold climates, tanks should have double covers, and the capacity must be great enough to allow for ice which may form 12 to 18 inches thick around the inside.

Underground Tanks

Where topography permits, concrete or steel storage tanks can be put below ground at an elevation that will permit gravity flow through the system. Under conditions where there is not sufficient elevation, a pressure system can be installed. An electric motor-driven deep well pump connected to a pneumatic tank affords the most practical system. Electric power is quite essential if continuous flow is to be provided with little storage capacity, as this type is readily adaptable to automatic starting and stopping due to pressure variations.

Tank Towers

Tank towers may be constructed of wood, steel, or other materials.

The tower should be strong enough to hold the storage tank and water for the maximum anticipated installations, and must be well braced to prevent damage from high winds. The height of the tower should be a minimum of 10 feet, and the bottom of the tank should be at least eight feet above the highest outlet in the water line. Towers may be enclosed to form a milk house and wash house. In this case a concrete floor with drain should be provided and a milk box installed. Figure 16 shows a typical wooden tower. For larger wooden towers and towers of other types, the District Engineer's office should be consulted. Steel towers can be obtained from any reliable dealer.

Supply Pipe from Storage Tank

This should be a one or two-inch pipe depending upon the elevation of the highest outlet and its distance from the storage tank.

Table 3 gives the carrying capacities of ½-inch to 2½-inch pipes for varying heads and lengths. Loss of head due to the friction of water in pipe has been taken into consideration in preparing the table.

The friction loss caused by placing elbows or valves in a pipeline is equivalent to adding more length, and these equivalents are given at the bottom of the table.

Two examples are given to show the use of the table:

Example 1 -

How much water will be delivered by 150 feet of 3/4-inch pipe if the outlet is 12 feet lower than the inlet (head is 12 feet)? The pipeline contains two 90-degree elbows and one globe valve.

Solution -

From Table 3 the friction loss of each 90-degree elbow is equivalent to six feet of pipe, and of each 3/4-inch globe valve, nine feet of pipe or a total of 21 feet. This added to the 150 feet of pipe gives an equivalent length of 171 feet. 171 feet of 3/4-inch pipe with a 12-foot head will deliver four gallons per minute.

Example 2 -

What size pipe will be required to deliver 10 gallons of water per minute with a head of 16 feet? The pipeline will be 480 feet long and will have two globe valves in it.

Solution -

From inspection of Table 3 it is found that the size

TABLE 3

MAXIMUM ALLOWABLE LENGTH OF PIPE IN FEET FOR GALLONS PER MINUTE FLOW

Head	3 Gal per Min			4 Gallons per Minute					5 Gallons per Minute					10 Gallons per Minute						
in Feet	½" Pipe	3/4" Pipe	1" Pipe	½" Pipe	3/4" Pipe	1" Pipe	1¼" Pipe	1½" Pipe	½" Pipe	3/4" Pipe	1" Pipe	1¼" Pipe	1½" Pipe	½" Pipe	3/4" Pipe	1" Pipe	1¼" Pipe	1½" Pipe	2" Pipe	2½" Pipe
2	12	48	158	6	28	93	350	769	4	18	61	238	512	1	4	17	65	139	400	1176
4	25	97	317	14	57	186	701	1538	9	38	123	476	1025	2	9	34	131	279	800	2352
6	37	146	476	22	85	280	1052	2307	14	57	184	714	1438	3	14	51	196	419	1200	3529
8	50	195	634	29	114	373	1403	3076	19	76	246	952	2051	4	20	68	262	559	1600	4705
10	63	243	793	37	142	467	1754	3846	24	95	307	1190	2564	6	25	85	327	699	2000	5882
12	75	292	952	44	171	560	2105	4615	29	114	369	1428	3076	7	31	102	393	839	2400	7058
14	88	341	1111	51	200	654	2456	5384	34	133	430	1666	3589	8	36	119	459	979	2800	8235
16	101	390	1269	59	228	747	2807	6153	39	152	492	1904	4102	10	42	136	524	1118	3200	9411
18	113	439	1428	66	257	841	3157	6923	44	171	553	2142	4615	11	47	153	590	1258	3600	10588
20	126	487	1587	74	285	934	3508	7692	49	190	615	2380	5128	13	52	170	655	1398	4000	11764
22	139	536	1746	81	314	1028	3859	8461	53	209	676	2619	5641	14	57	188	721	1538	4400	12941
24	151	585	1904	88	342	1121	4210	9230	58	228	738	2857	6153	15	63	205	786	1678	4800	14117
26	164	634	2063	96	371	1214	4561	9999	63	247	799	3095	6666	16	68	222	852	1818	5200	15294
28	177	682	2222	103	400	1308	4912	10769	68	266	861	3333	7179	18	73	239	918	1958	5600	16470
30	189	731	2380	110	428	1401	5263	11538	73	285	923	3571	7692	19	78	256	983	2097	6000	17647
32	202	780	2539	118	457	1495	5614	12307	78	304	984	3809	8205	21	84	273	1049	2237	6400	18823
34	215	829	2698	125	485	1588	5964	13076	82	323	1046	4047	8717	23	89	290	1114	2377	6800	19999
36	227	878	2857	133	514	1682	6315	13846	87	342	1107	4285	9230	24	94	307	1180	2517	7200	21176
40	253	975	3174	148	571	1869	7017	15384	97	380	1230	4761	10256	27	105	341	1311	2797	8000	23529
45	284	1097	3571	166	642	2102	7894	17307	109	428	1384	5357	11538	30	118	384	1475	3146	9000	26470
50	316	1219	3968	185	714	2336	8771	19230	121	476	1538	5952	12820	34	131	427	1639	3496	10000	29411

Size of pipe in inches	½	3/4	1	1¼ to 2	2½
Feet of pipe to be subtracted from above table for each 90 degree elbow or tee	5	6	6	8	11
Feet of pipe to be subtracted from above table for each globe valve	8	9	9	12	17

will fall somewhere between one inch and two inches. The equivalent length of pipe for two globe valves of this size is 24 feet. This added to the 480 feet of pipe required gives an equivalent pipe line length of 504 feet. From the table the longest length of one inch pipe that will deliver 10 gallons of water per minute with a 16-foot head is 136 feet. It is therefore necessary to go to the column for $1\frac{1}{4}$-inch pipe where the desired capacity can be had up to 524 feet of pipe.

Where complicated installations are encountered, pipe manufacturers or the District Engineer's office can advise what size pipe should be used. In many instances the intake pipe and the outlet pipe can be combined from the base of the tower to the tank. Figure 16 illustrates this type of construction.

All exposed portions of the pipe must be insulated. Figure 16 shows an approved method of insulation. Absorbent insulating materials should not be placed in direct contact with iron or steel pipes since these materials will become damp due to "sweating" of the pipe and lose their insulation qualities. All pipes leading to the house, barn, or stock tanks must be below the frost line to assure protection from freezing. Usual depths of underground piping for frost protection are given below:

Colorado-------3 to 5 feet
Wyoming -------5 to 6 feet
Montana -------5 to 7 feet

Stock Tanks

Tanks for watering livestock may be constructed of wood, metal or concrete. In some localities, earthen tanks lined with clay or Bentonite have been used successfully. For windmill installations the capacity should be about five times the daily water requirement of the stock unless excessive storage is provided elsewhere. A cover should be provided to keep out small animals and chickens.

All tanks should be supplied by a pipe large enough to deliver four or five gallons per minute. The proper size may be obtained from Table 3. Figure 17 shows a typical installation.

VIII DISINFECTION

New Equipment

Whenever a new source of drinking water is developed, it must

be disinfected thoroughly before being put into use. This disinfection should not be confused with the treatment of the water itself. It is done to assure the cleansing of all new equipment and construction, and requires a stronger solution than is used in the sterilization of drinking water.

Disinfection can be done with calcium hypochlorite, better known as chlorinated lime or bleaching powder, containing about 30 per cent available chlorine. A solution of approximately 50 p.p.m. (parts per million) available chlorine should be used to effect complete and proper cleansing of all interior walls of springs, wells, cisterns, and storage tanks. A concentrated solution may be prepared by dissolving fresh chlorinated lime in water in proportions of one ounce (two level tablespoonfuls) of lime to a gallon of water. A proper amount of this solution may then be poured into the well or spring encasement. Table 4 shows the quantity to be used. In order to have the side walls of drilled wells thoroughly washed down, it is advisable to pump the solution out and pour it back into the well one or more times.

The side walls of dug wells, spring encasements, storage tanks and cisterns should be scrubbed with disinfectant made by diluting one pint of the concentrated solution in five gallons of water. A clean, long-handled broom may be used for applying the disinfectant. New pipe and pumps may also be washed with this diluted solution.

Drinking Water

The disinfection of drinking water by home methods should be considered an emergency measure. The purity of water is often suspected before the existence of disease becomes definitely known. Suspicion may be created by minor intestinal ailments or by odor or taste of the water. Pending examination by a competent sanitation authority, the householder should boil all water used for drinking and cooking purposes.

County or State Health Authorities will determine the amount and kind of disinfectant for each particular water. These matters are guesswork with the average individual. He may guess wrong, and his efforts to disinfect drinking water may lead to a false sense of safety. For these reasons absolute reliance cannot be placed upon home methods of sterilizing water with chemicals.

As a temporary precaution against disease, however, water may be treated with chlorinated lime as outlined in Table 4. When

TABLE 4
PURIFICATION BY CHLORINATED LIME

Diameter of Well, Tank, or Cistern	Gallons of Water Per Vertical Ft.	Amount of Concentrated Solution* to be Added per Vertical Foot of Water	
		For Sterilizing New Equipment	For Disinfecting Drinking Water
2"	0.16	1 tablespoonful	1/10 teaspoonful
4"	0.65	4 tablespoonfuls	½ teaspoonful
6"	1.47	9 tablespoonfuls	1 teaspoonful
8"	2.61	½ pint	2 teaspoonfuls
10"	4.08	3/4 pint	1 tablespoonful
12"	5.88	1 pint	1½ tablespoonfuls
2'	23.50	4½ pints	6 tablespoonfuls
3'	52.88	4½ quarts	13½ tablespoonfuls
4'	94.03	8½ quarts	24½ tablespoonfuls
5'	146.84	3½ gallons	1¼ pints
6'	211.47	4-3/4 gallons	1-3/4 pints
7'	287.85	6½ gallons	2¼ pints
8'	376.05	8½ gallons	1½ quarts
9'	475.91	11 gallons	2 quarts
10'	587.52	13½ gallons	2½ quarts
11'	710.87	15 gallons	2-3/4 quarts
12'	846.05	19 gallons	3½ quarts

* Concentrated solution prepared by dissolving one ounce (two level tablespoonfuls) of chlorinated lime in one gallon of water.

3 teaspoonfuls = 1 tablespoonful　　2 pints = 1 quart

32 tablespoonfuls = 1 pint　　4 quarts = 1 gallon

using this method the concentrated solution of chlorinated lime should be well mixed with the water, which should be fit to drink after five or six hours. The chlorine taste will disappear in a few days.

The foregoing treatment is effective only for the water in the well or cistern at the time the chlorine solution is added. Subsequent water entering the well or cistern is not affected, and may even pollute the treated water.

IX GARDEN IRRIGATION

In many instances the farmstead water supply is sufficient to irrigate a small garden in addition to supplying domestic and stock water. Detailed garden irrigation instructions are contained in "Irrigation of the Farm Garden", copies of which may be obtained by writing to the regional office of the Farm Security Administration in Denver, Colorado.

APPENDIX

For conditions not covered by the plans and specifications contained in this Manual, consult the Office of the District Engineer.

CONCRETE SPECIFICATIONS

Concrete

Concrete is made by combining water with portland cement, sand, and gravel. In describing a mix, the parts of cement and parts of aggregate are usually expressed in the manner 1:2:4, indicating that one cubic foot of cement is used with two cubic feet of sand and four cubic feet of gravel.

Cement

Portland cement is commonly obtained in paper bags or cloth sacks. A sack of cement weighs 94 pounds and contains one cubic foot. Any cement containing lumps so hard that they do not readily pulverize when struck lightly with a shovel should not be used.

Aggregate

Sand should be clean, hard, and well graded, that is with particles of many sizes from very fine up to those which will pass through a wire screen with 1/4-inch mesh. Coarse aggregate or gravel should be clean, hard, and range in size from 1/4 inch up to about 1-1/2 inches for most work. A considerable portion of flat or elongated pieces should be avoided.

Bank-run aggregate, frequently called bank or pit gravel, often is used just as it comes from the pit or creek. A test to determine whether it contains approximately the right balance of sand and gravel is made by selecting a representative sample of at least two cubic feet and screening it over a 1/4-inch mesh screen. The part passing through the screen is considered sand, while the part retained is gravel. Unless the sand and gravel exist in approximately the right ratios, they should be separated by screening and remixed in correct proportions.

Silt, clay and loam are objectionable in aggregate to be used in making concrete as they coat the particles and prevent the cement paste from bonding to them, resulting in weak, porous concrete.

Test for Silt

If there is any question as to whether the sand or gravel is clean enough to make good concrete, a silt test should be made. Two inches of a representative sample of aggregate is placed in an ordinary pint fruit jar, and water is added until the jar is almost full. The cover is fastened and the jar is shaken vigorously for about one minute, and then the contents are allowed

to settle until the water over the material clears. If the layer of silt on top of the aggregate is more than 1/8 of an inch thick, the aggregate is unsuitable for concrete unless washed before using.

Test For Organic Impurities

The presence of harmful amounts of vegetable matter in aggregate can be determined by a simple test (except in areas where there are deposits of lignite). In making this test a heaping teaspoonful of household lye is dissolved thoroughly in 1/2 pint of clear water. This solution is poured into a glass jar containing 1/2 pint of representative aggregate. The jar is covered tightly and shaken vigorously for one or two minutes then set aside for 24 hours. A clear or straw colored liquid indicates aggregate suitable for concrete. Colors darker than apple cider vinegar show excessive amounts of organic matter, in which case the aggregate should not be used unless washed and found safe after retesting. This test is very valuable in localities where trouble has been experienced in getting concrete to harden properly.

Water

Water for concrete should be clean enough to drink. Alkali salts are destructive if in excess of 0.5%.

Mixing Concrete

Good, durable concrete can be obtained by exercising care in mixing and placing. All materials should be accurately measured. It is especially important that only a limited, measured amount of water be used for each sack of cement. When too much water is added, the cement paste which holds the mass of sand and gravel together will be diluted and weak, resulting in a weak, porous concrete.

A general guide to follow is to use five gallons of water to each sack of cement and vary the proportions of sand according to the size of the gravel. Table 5 gives recommended mixtures for different classes of work. These are trial mixes for average conditions, and the proportions of sand and gravel may be varied slightly if necessary to obtain workable mixes. For most work a workable mix is one which is "mushy" but not "soupy". Under no circumstances should the quantity of water specified per sack of cement be changed.

Concrete for cisterns should be mixed by machine. Two minutes

TABLE 5

RECOMMENDED MIXTURES FOR SEVERAL CLASSES OF CONSTRUCTION

	Gallons of Water Per Sack of Cement			Sand and Gravel Per Sack of Cement		Approximate Amounts Of Materials Required Per Cubic Yard Of Concrete			Largest Size of Gravel
	Very Wet Sand	Average Sand	Dust Dry Sand	Cubic Feet Of Sand	Cubic Feet Of Gravel	Sacks of Cement	Cubic Yards of Sand	Cubic Yards of Gravel	
Most farm construction such as floors, steps, basement walls, walks, yard pavements, silos, grain bins, and cisterns.	4	5	$5\frac{1}{2}$	2-1/4	3	$6\frac{1}{4}$	3/4	4/5	$1\frac{1}{2}$"
Concrete in thick sections and not subject to freezing. Thick footings, thick foundations, retaining walls, engine bases.	$4\frac{1}{2}$	$5\frac{1}{2}$	6	2-3/4	4	5	3/4	4/5	$1\frac{1}{2}$"
Thin reinforced concrete such as milk-cooling tanks, fence posts, thin floors, most uses where concrete is two to four inches thick.	4	5	$5\frac{1}{2}$	2-1/4	$2\frac{1}{2}$	$6\frac{1}{2}$	3/4	4/5	3/4"
Very thin concrete such as top course of two course pavements and floors, concrete furniture and most cases where concrete is one to two inches thick.	3	4	$4\frac{1}{2}$	1-3/4	$2\frac{1}{4}$	8	3/4	4/5	3/8"

mixing time should be allowed after all materials are in the mixer. Where water tightness is not required, concrete may be mixed by hand. When mixing by hand, the process should be continued until the mass is of uniform consistency.

Precautions must be taken in placing concrete in order to secure best results. Forms should be wet thoroughly or oiled. Freshly mixed concrete should be deposited immediately in horizontal layers, preferably not over six inches thick, and a spade, paddle, or straightened hoe should be worked up and down against the forms to push the coarse material away from the surface and eliminate air pockets. If an appreciable amount of water comes to the top while spading, it is a warning that the mix is too wet. If the correct amount of water is being used as specified in Table 5, a wet mix may be corrected by increasing slightly the amounts of sand and gravel in subsequent batches. Construction joints caused by stopping work temporarily demand special attention. For best results the surface should be roughened with a stiff broom or wire brush before it hardens. Before placing new concrete the surface should be dampened and covered with cement mortar about 1/2 inch thick. Cement mortar consists of one part of cement to 2-1/2 parts of sand with enough water to make a workable mix.

Curing

Two conditions are necessary for the proper setting of concrete: the presence of moisture and a favorable temperature. Materials commonly utilized for protecting concrete while curing are canvas, burlap, boards, layers of sand, and straw. These should be placed as soon as practicable without marring the concrete surface, and should be kept continuously moist for a period of at least one week.

If concrete work is to be done in cold weather, it must be protected from freezing until it has set thoroughly. All aggregates and water should be heated so that the concrete when placed will be between 70 degrees and 100 degrees F. Concrete should not be deposited on frozen ground or in forms containing frost or ice, and it should be maintained at 50 degrees F. for at least five days.

Reinforced Concrete

Concrete is strong in compression but weak in tension, therefore standard mesh or steel is used to reinforce those sections subject to stretching. A heavy grade of hog wire may be used on non-critical sections, but it will stretch when a strain is

applied and should not be relied upon in place of standard reinforcing bars. In general, all reinforcement should be accurately placed according to the plans and protected by a covering of at least one inch of concrete.

Surface Finish

Imperfections do not necessarily affect the strength of the concrete, but they do detract from appearance and water tightness. Rubbing off form marks and pointing up depressions or holes gives a smoother appearance to the work. This may be done with a wooden float or hard burned brick, using sand and water as an abrasive. A 1:2 mortar is satisfactory for pointing up. The surface can be worked best if the forms are removed before the concrete has set too hard (8 to 10 hours in warm weather, 24 to 48 hours in cold weather). A carborundum block may be used for rubbing hard concrete. The common practice of giving the surface a coat of cement mortar grout is undesirable as this layer will tend to peel off in a few years. Excessive use of a trowel or float draws fine materials to the surface resulting in poor wearing qualitites.

Quantities of Material

A common mistake to be guarded against is to assume that the volume of concrete produced will be equal to the sum of the amounts of sand and gravel used. Since the sand will fill the spaces between the gravel particles, and the cement and water will fill the spaces between the sand particles, the final amount of concrete obtained will be approximately the same as the amount of gravel used. The average quantities of concrete per sack of cement for different mixes is shown in Table 5. When bank-run aggregate of correct proportions is used, a 1:4 mixture is considered equivalent to 1:2½:3 and a 1:5 mixture equivalent to 1:2-3/4:4.

SPECIFICATIONS FOR STEEL WINDMILLS AND TOWERS

WINDMILL

Type

The windmill shall be of the self-oiling type with an enclosed gear case that requires the changing of oil only once every twelve months.

Size

The wheel shall be of sufficient size to pump the required amount of water with normal wind velocities.

Gears

For wells deeper than 125 feet, machine-cut equalizing gears, working independently of each other on a high carbon steel bearing are required.

Bearings

Wheel and gear shafts shall be fitted with self-oiling, high-grade roller, ball, or bronze bearings.

Turntable

The turntable shall be equipped with self-aligning ball bearings protected from the weather, and must operate freely in a light breeze.

Governor

The mill must have an automatic regulating device that assures proper speeds at all times, responding quickly to variations of the wind without jerking or racking.

Brakes

A positive means to stop and hold the wheel when it is pulled out of the wind must be provided.

Shut-off Device

A simple, sturdy shut-off device, easily operated under all conditions must be provided. A spring bumper to absorb the shock when the mill goes into the wind is required.

Sails

Wheel sails shall be manufactured from heavy gage sheet steel, well formed and securely fastened in place.

Galvanizing

All exposed surfaces of the windmill except those that are ordinarily painted, shall be heavily galvanized. The galvanizing shall be by the hot process and consist of a heavy coating of spelter of not less than $1\frac{1}{4}$ ounces per square foot, evenly and uniformly distributed over all surfaces of exposed metal parts. Any spelter which peels, cracks, or blisters under ordinary handling shall be prima facie evidence of poor workmanship and cause for rejection. All bolts, nuts and braces shall be galvanized or cadmium plated.

TOWER

The tower shall be of the 4-post type of sufficient height to put the wheel at least ten feet above obstructions within 400 feet. It shall be designed to withstand a wind pressure of 25 pounds per square foot of projected area of tower and windmill. It shall be furnished complete with a ladder securely fastened to the tower, a substantial platform properly located to permit ready access to the motor for repairs and maintenance, long anchor posts and substantial anchors, and complete instructions.

Girts

Girts shall be of angle steel of adequate cross section to give proper stability to the tower specified, and shall be spaced approximately $5\frac{1}{2}$ feet apart.

Braces

The tower shall be adequately braced to prevent twisting or deformation of tower members. The braces shall be adjustable or capable of giving uniform tension at all times.

Pump Rod and Guides

The tower shall be equipped with a pump rod and sufficient pump rod guides to keep the rod in proper alignment without binding or interfering with the action of the rod.

Galvanizing

All metal portions of the tower shall be galvanized. The gal-

vanizing shall be not less than two ounces per square foot, evenly and uniformly distributed over all surfaces of exposed metal parts. Any spelter which peels, cracks, or blisters under ordinary handling shall be prima facie evidence of poor workmanship and cause for rejection. All bolts, nuts and braces shall be galvanized or cadmium plated.

ESTIMATE SCHEDULE
DOMESTIC AND STOCK WATER SUPPLY INSTALLATIONS

DAILY WATER REQUIREMENTS

1. ______persons @ 35 gallons per day............ _____gallons
2. ______horses and mules @ 15 gallons per day.... _____gallons
3. ______beef cattle @ 15 gallons per day......... _____gallons
4. ______dairy cows @ 30 to 40 gallons per day.... _____gallons
5. ______sheep and goats @ 1 to 2 gallons per day. _____gallons
6. ______mature hogs @ 2 to 3 gallons per day..... _____gallons
7. ______shoats @ 1½ gallons per day.............. _____gallons
8. ______chickens @ 3 gallons per 100 per day..... _____gallons
9. ______turkeys @ 7 gallons per 100 per day...... _____gallons
10. ______square feet of garden 165 gallons per hundred square feet per day........... _____gallons
11. ______ gallons per day _____gallons

Total Water Requirements In Gallons Per Day........__________

CISTERN

1. Diameter_____feet. Type______________________
2. Depth_____feet.
3. ______bricks @ $______per 1000..................... $________
4. ______sacks of cement @ $_____per sack.............. $________
5. ______feet of ½"Ø steel bars @ $_____per foot....... $________
6. ______sq. ft. of mesh @ $_____per square foot....... $________
7. ______hours of skilled labor @ $_____per hour....... $________
8. ______ @ $_____ $________

Total Cost of Cistern..........$__________

WELL

1. Size of hole_____inches Depth of hole_____feet

2. Size of casing_____inches Length of casing_____feet

3. Cost Per Foot for drilling and casing $_____

Total Cost of Cased Hole........... $_________

Cost of Screen in Place............ $_________

CYLINDER

1. Size_____inches Stroke_____inches Cost.... $_________

DROP PIPE AND RISER PIPE

1. Size_____inches (larger than cylinder)

2. Length_____feet (include riser pipe to storage tank)

3. Cost per foot $_____ Total Cost Of Pipe.......... $_________

4. Fittings:

a._______inch tee @ $_____each.......... $_______

b._______inch reducing tee @ $_____each. $_______

c._______inch reducing tee @ $_____each. $_______

d._______inch cap @ $_____each.......... $_______

e._______inch faucet @ $_____each....... $_______

f._______inch nipple @ $_____each....... $_______

g.____________________ @ $_____each... $_______

Total Cost of Fittings...... $_________

HAND PUMP

1. Type________________________________

2. Make________________________________

Cost...... $_________

POWER PUMP

1. Type ____________________

2. Make ____________________

Cost...... $________

WINDMILL

1. Size ____ feet

Cost...... $________

PUMP ROD

1. Size ____ inches Material ____________

2. Length ____ feet

3. Cost per foot $____

Total Cost...... $________

WINDMILL TOWER

1. Height ____ feet Material ____________

Cost...... $________

ELEVATED STORAGE TANK

1. Capacity ____ gallons Material ____________

Cost...... $________

STORAGE TANK TOWER

1. Height ____ feet Material ____________

2. Enclosed: Yes ____ No ____

3. Milk box: Yes ____ No ____

Cost...... $________

STOCK TANKS

1. Capacity______gallons Type____________________

Cost...... $_______

2. Capacity______gallons Type____________________

Cost...... $_______

3. Capacity______gallons Type____________________

Cost...... $_______

Total Cost of Stock Tanks....... $_________

ADDITIONAL INSTALLATIONS AND COSTS

1. Pipe:

   a. Size_____inches

   b. Length_____feet

   c. Cost per foot $_____ Total Cost of Pipe............. $_________

2. Fittings:

   a. _____inch couplings @ $_____each....... $_________

   b. _____90° ells @ $_____each............ $_________

   c. _____45° ells @ $_____each............ $_________

   d. _____inch tees @ $_____each........... $_________

   e. _____inch reducing tees @ $_____each... $_________

   f. _____inch street ell @ $_____each...... $_________

   g. _____inch caps @ $_____each........... $_________

   h. _____inch unions @ $_____each.......... $_________

   i. _____inch nipples @ $_____each......... $_________

   j. _____inch reducing bushings @ $_____each $_________

   k. _____inch plugs @ $_____each........... $_________

   l. _____inch valves @ $_____each.......... $_________

   m. _____inch stop and waste @ $_____each.. $_________

   n. _____ @ $_____each.. $_________

   o. _____ @ $_____each.. $_________

   p. _____ @ $_____each.. $_________

Total Cost.................... $_________

FARMER LABOR ESTIMATE

1. Man hours to construct cistern................ ______
2. Man hours to install drop pipe and riser pipe.. ______
3. Man hours to install hand pump................ ______
4. Man hours to install power pump............... ______
5. Man hours to erect windmill tower............. ______
6. Man hours to install windmill................. ______
7. Man hours to install pump rod................. ______
8. Man hours to erect storage tank tower.......... ______
9. Man hours to assemble storage tank in place.... ______
10. Man hours to install stock tanks.............. ______
11. Man hours to install all pipe................. ______
12. .... ______
13. .... ______
14. .... ______
15. .... ______
16. .... ______
17. .... ______
18. .... ______

Total Man Hours Contributed..... ______

Rate Per Hour.......... $______

Total Farmer Labor Contribution........$__________

Cost of Materials, Equipment, and Skilled Labor.......$__________

Contingencies---10%...................................$__________

ESTIMATED COST OF COMPLETE INSTALLATION...............$__________

S. C. S.-656A

UNITED STATES DEPARTMENT OF AGRICULTURE
~~[illegible]~~
Farm Security Administration

ESTIMATE AND COST REPORT

State Colorado
Name (area or county) Las Animas
W. F.—Area ☒ or demonstration ☐ (check one).
Type—Individual ☒ or group ☐ (check one).
Farm plan or group plans—No.
Installed by ~~[illegible]~~ ☐ or farmer(s) ☒ (check one).

Date Feb. 20, 1943 Work order No.
Number families involved 1
Name of farmer or group John Doe
Acres in farm(s) 360
Technician Frank Jones

Description of work Drill, case, and develop well; install windmill and pump

ESTIMATED AND ACTUAL FIGURES ON WORK

ITEM	UNIT	ESTIMATED					ACTUAL				
		Unit value	F.S.A.		Farmer(s)		Unit cost	F.S.A.		Farmer(s)	
			Quantity	Cost	Quantity	Cost		Quantity	Cost	Quantity	Cost
(a) Labor—supervisory											
Other											
Common	hr.	0.50			40	20.00				50	25.00
(b) Material											
Drill & case well	ft.	1.80	150	270.00			1.80	145	261.00		
2" galvanized drop pipe	ft.	0.35	140	49.00			0.35	135	47.25		
1-13/16"x16" cylinder	each		1	10.00				1	10.00		
7/16" pump rod	ft.	0.08	140	11.20			0.08	135	10.80		
Hand pump	each		1	15.00				1	15.00		
8 ft. windmill and 30 ft. steel tower	each		1	100.00				1	100.00		
(c) Equipment											
(d) Transportation											
$1\frac{1}{2}$ ton truck	mi.	0.10			40	4.00				40	4.00
TOTAL,				455.20		24.00			444.05		29.00

Work units ☐ ☐   ☐ ☐

Estimated { Total cost $479.20; Amount of repayment $455.20 }
Actual { Total cost $473.05; Amount of repayment $444.05 }

I HEREBY CERTIFY that installation of the above-described facility(ies) has been completed in accordance with the specification in the Water Facilities plan section of Farm Plan—Group Plans No.

Approved: Frank Jones Title RR Supervisor
Date installation started Feb. 12, 1943 Date installation completed and certified to F. S. A. Mar. 4, 1943

Approved as to date of completion.

John Doe
(Farmer(s) signature)

U. S. GOVERNMENT PRINTING OFFICE 8—12982

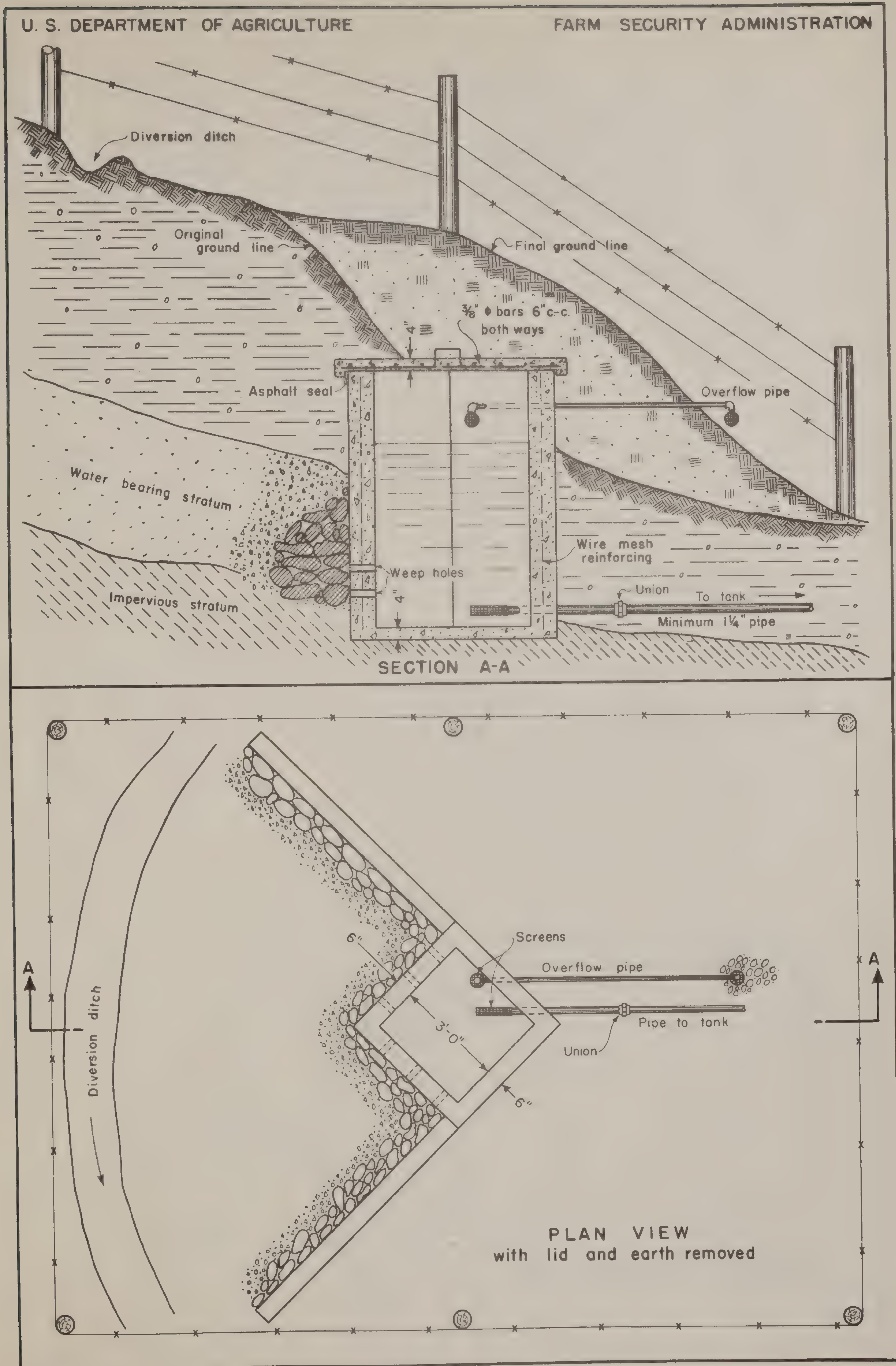


FIGURE 1.- Typical spring development

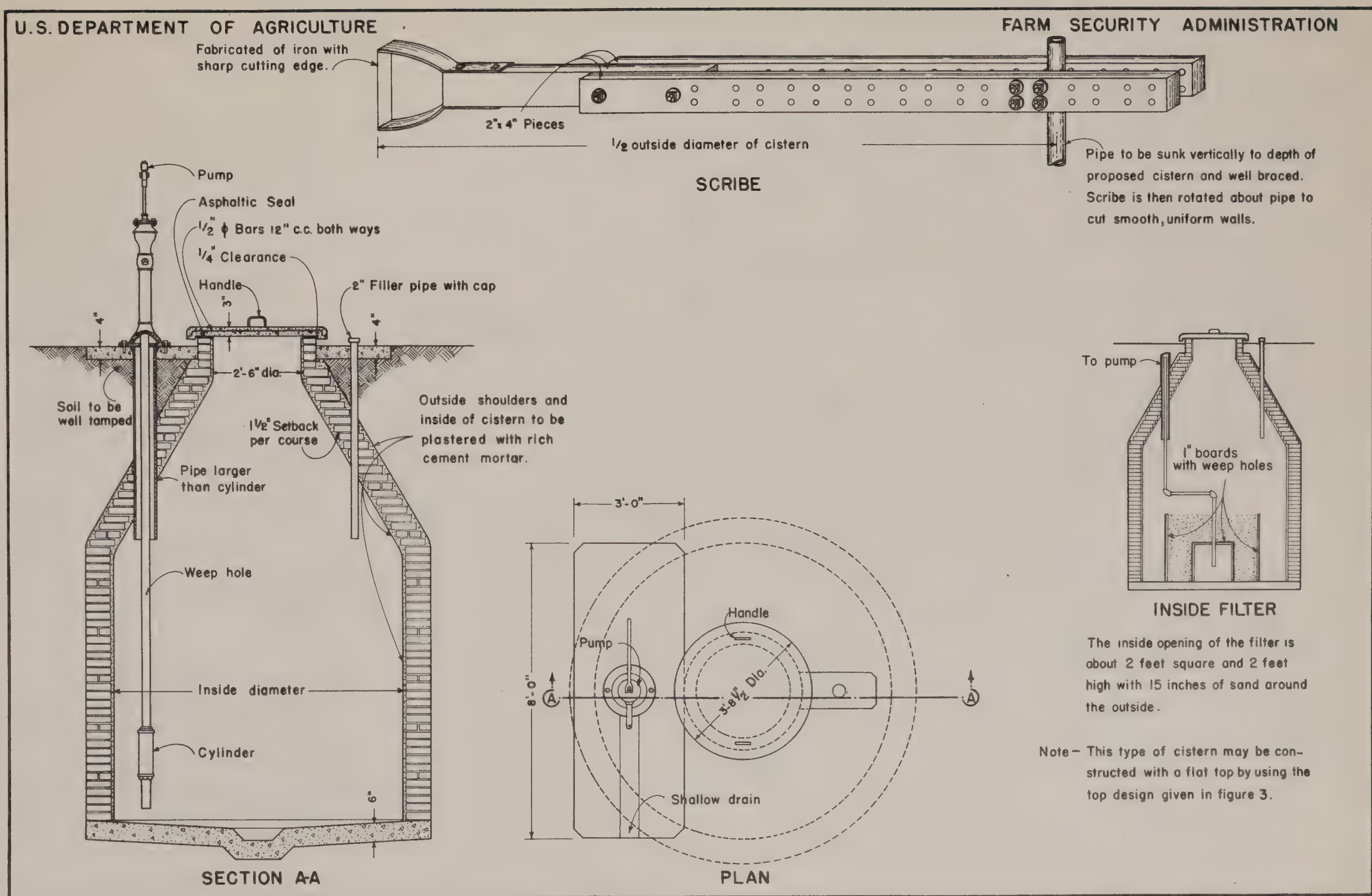
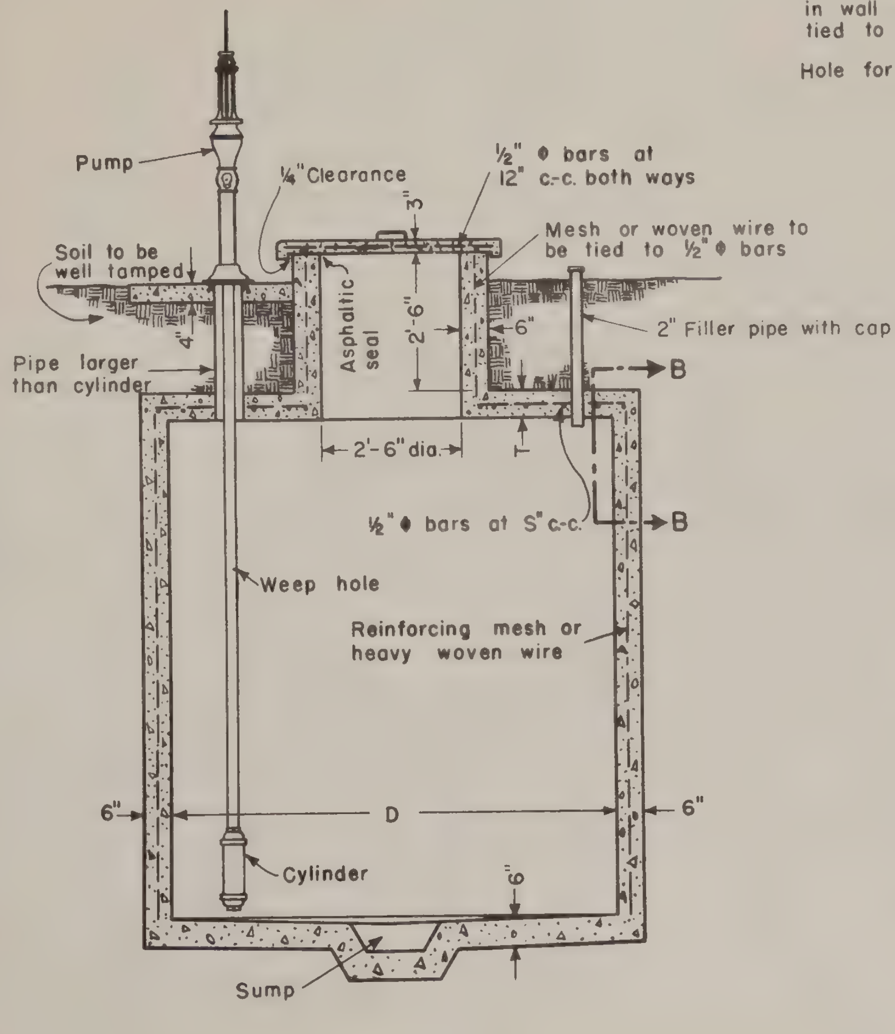


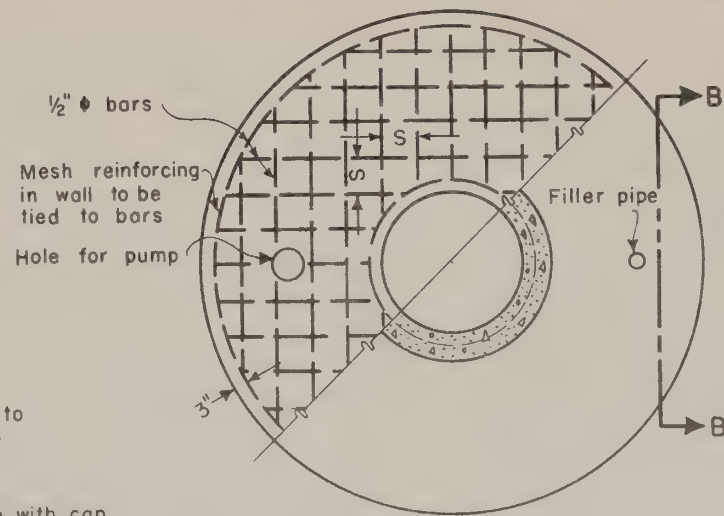
FIGURE 2.– Round Brick Cistern

U. S. DEPARTMENT OF AGRICULTURE

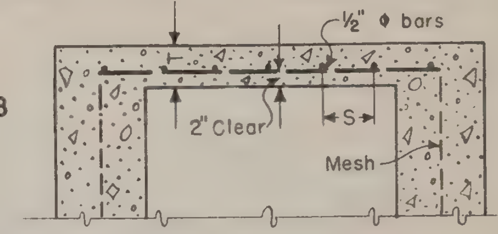
FARM SECURITY ADMINISTRATION



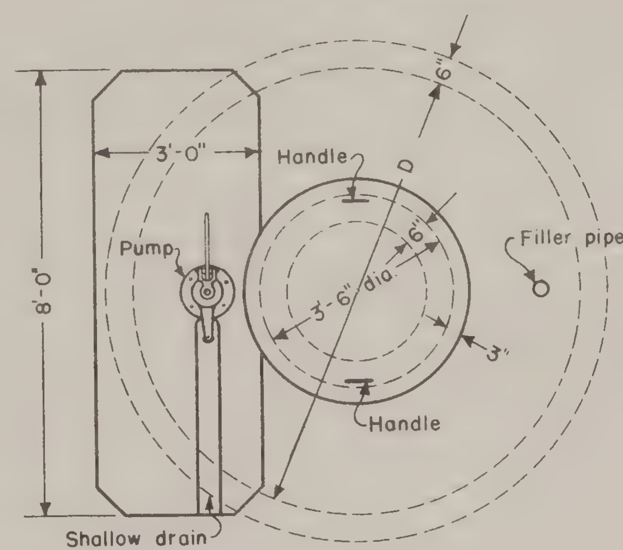
SECTION



DETAIL
TOP REINFORCING



ENLARGED SECTION B-B



PLAN

TOP DESIGN

D	T	S	FEET OF STEEL
5'	5 1/4"	12"	100
6'	5 1/4"	10 1/2"	140
7'	5 3/4"	9"	190
8'	6 1/4"	7 1/2"	260
9'	6 3/4"	6 1/2"	360
10'	7 1/4"	6"	470
11'	7 3/4"	5 1/2"	590
12'	7 3/4"	5"	730

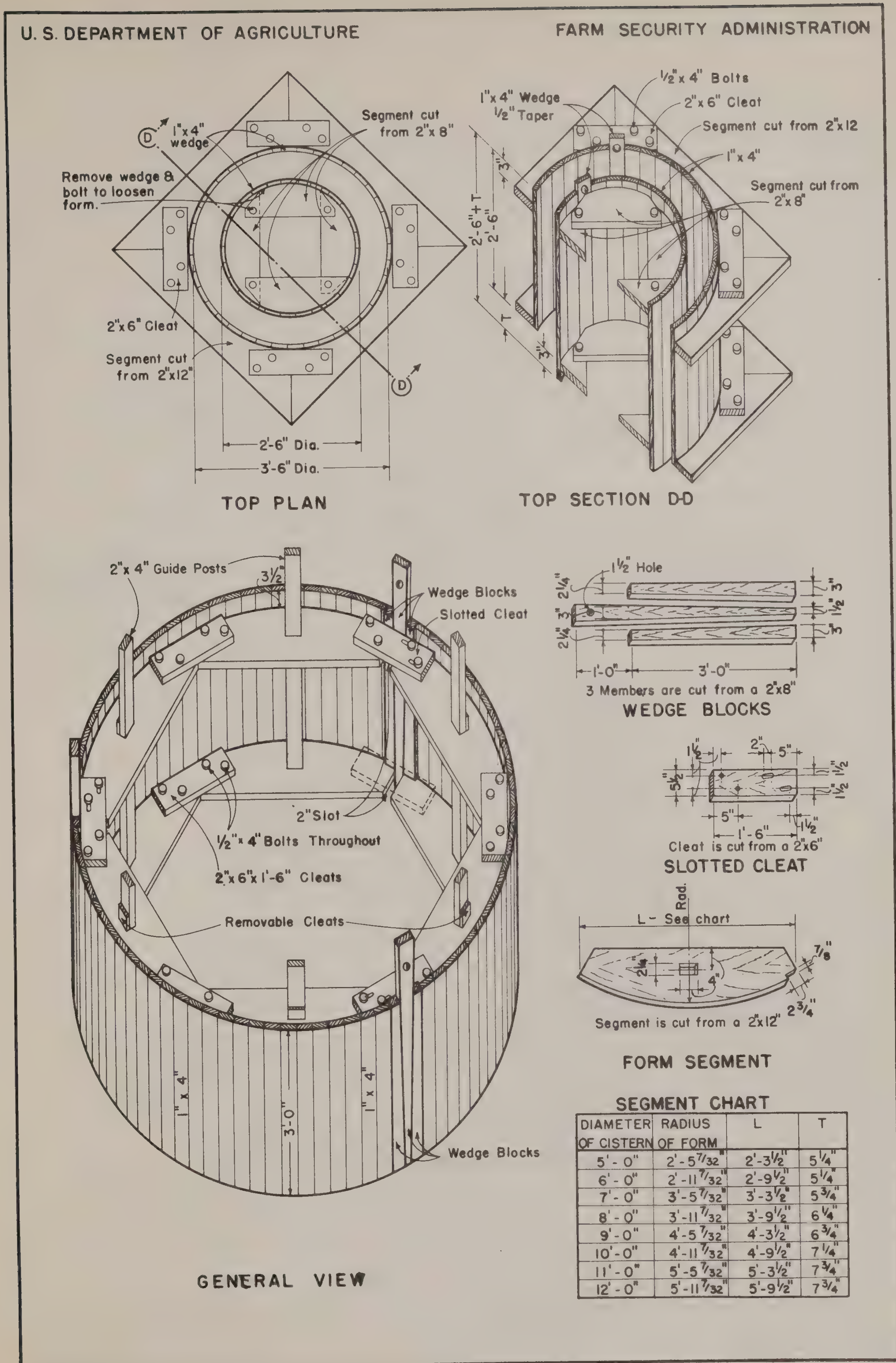
Notes:
All steel shown for top and cover is standard 1/2" ϕ (round deformed) bars.

Reinforcing bars must be accurately placed and wired together at all points of contact.

The scribe shown in figure 2 may be used to cut smooth earth walls, obviating the need of outside forms.

Inside or outside filters may be used if water is turbid.

FIGURE 3. – Round concrete cistern



SEGMENT CHART

DIAMETER OF CISTERN	RADIUS OF FORM	L	T
5' - 0"	2'-5 7/32"	2'-3½"	5¼"
6' - 0"	2'-11 7/32"	2'-9½"	5¼"
7' - 0"	3'-5 7/32"	3'-3½"	5¾"
8' - 0"	3'-11 7/32"	3'-9½"	6¼"
9' - 0"	4'-5 7/32"	4'-3½"	6¾"
10' - 0"	4'-11 7/32"	4'-9½"	7¼"
11' - 0"	5'-5 7/32"	5'-3½"	7¾"
12' - 0"	5'-11 7/32"	5'-9½"	7¾"

FIGURE 4.
Construction details of collapsible cistern forms

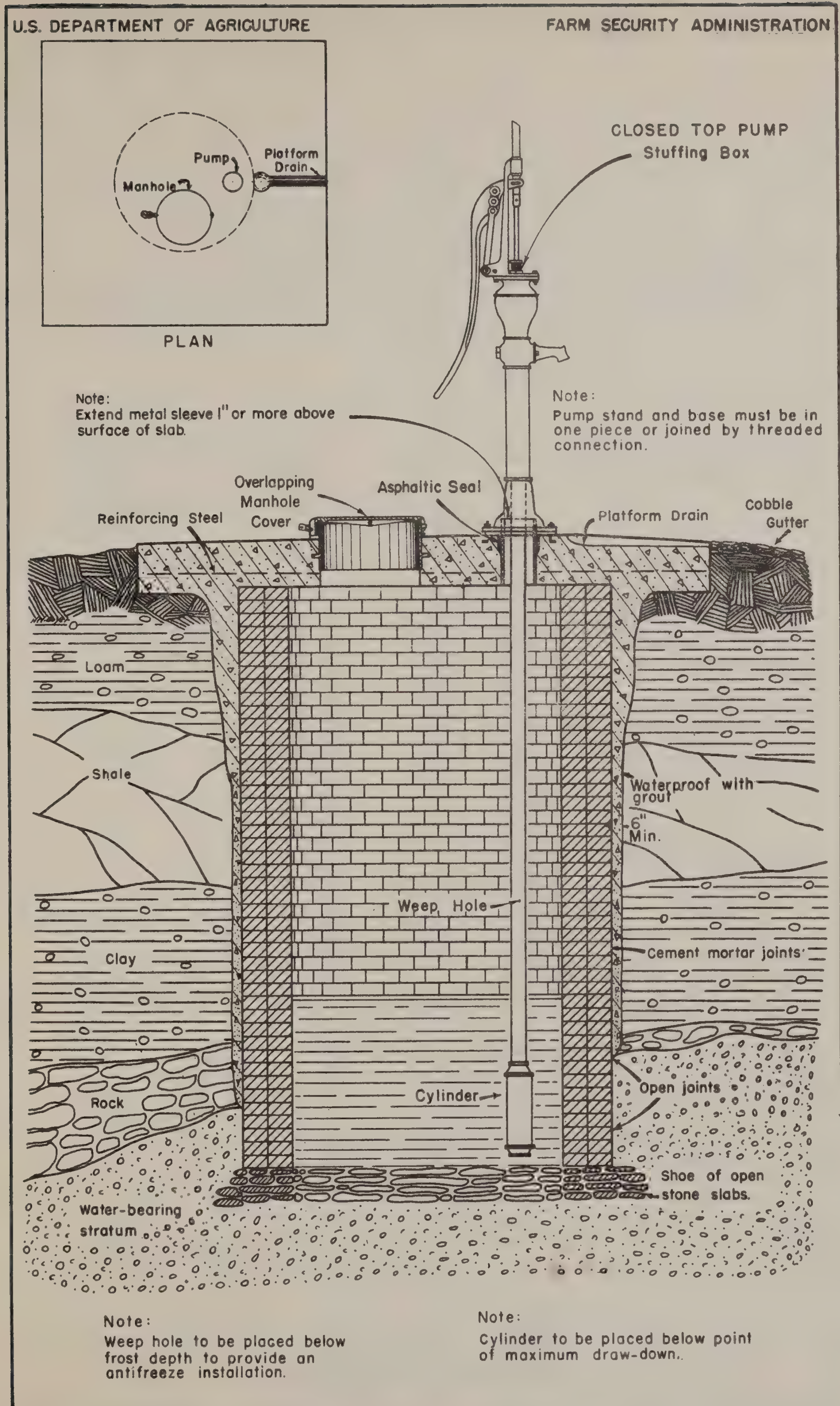


FIGURE 5.– Properly constructed dug well with brick curbing.

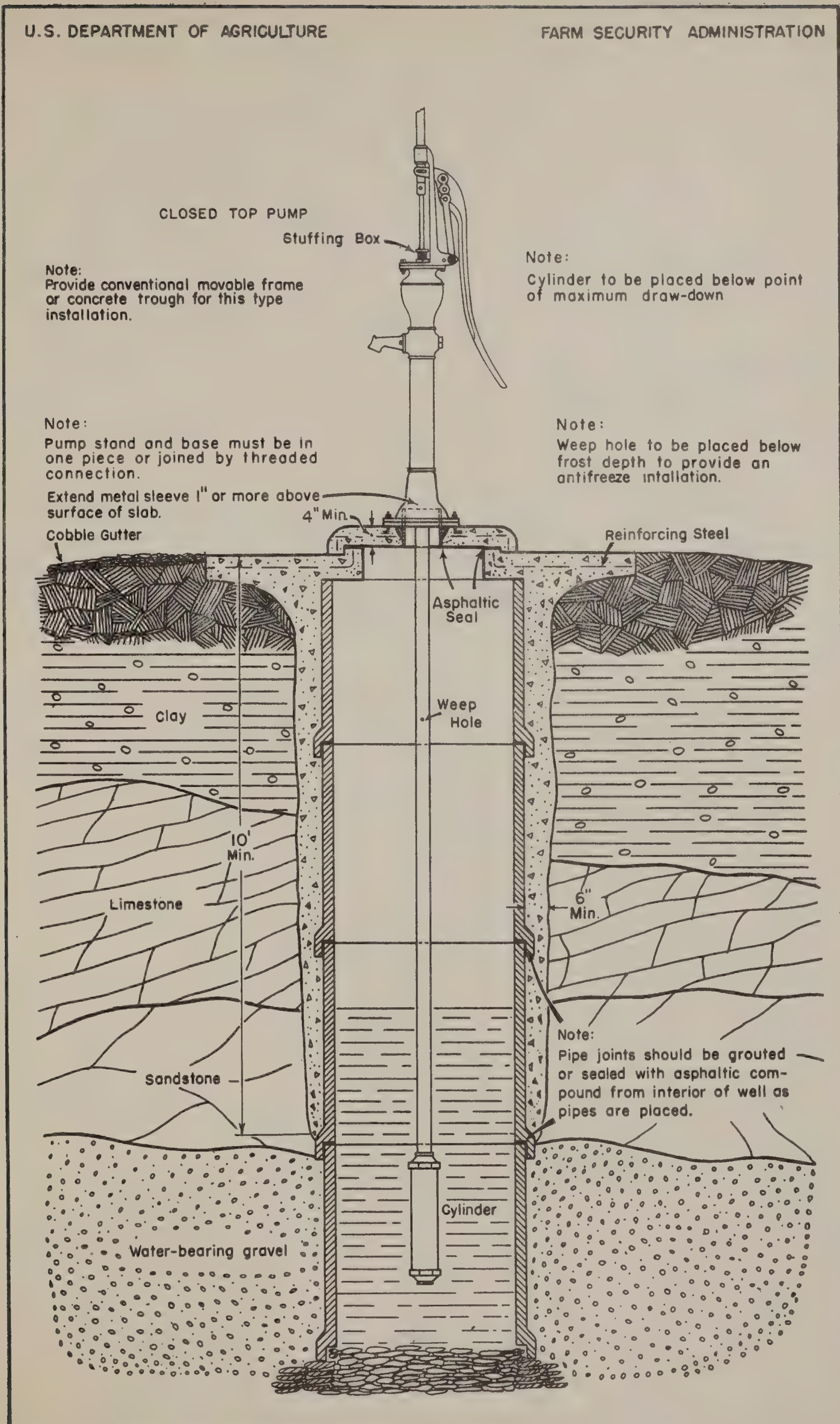


FIGURE 6.—Dug well properly cased with terra cotta pipe.

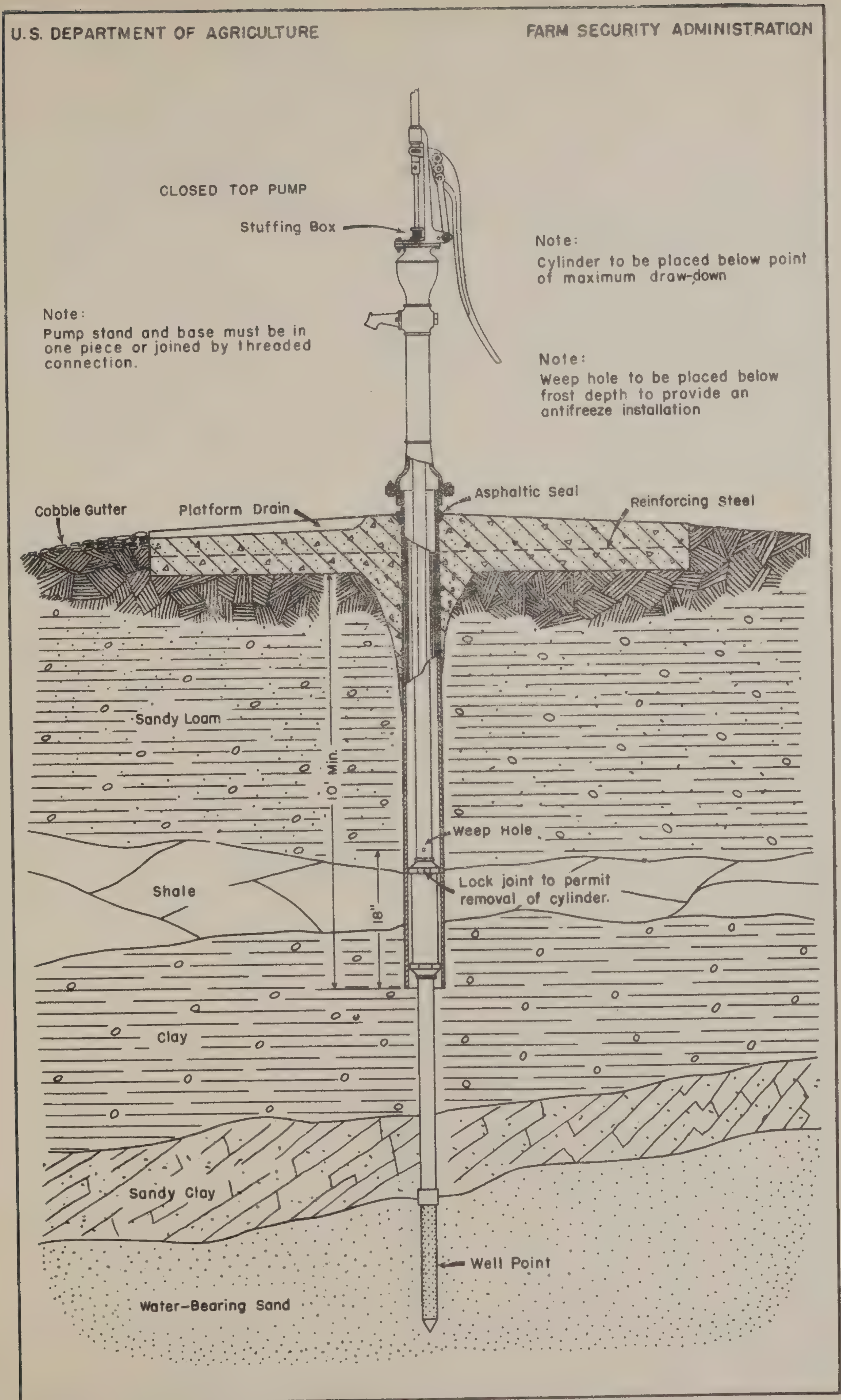


FIGURE 7.— Properly constructed driven well with well point.

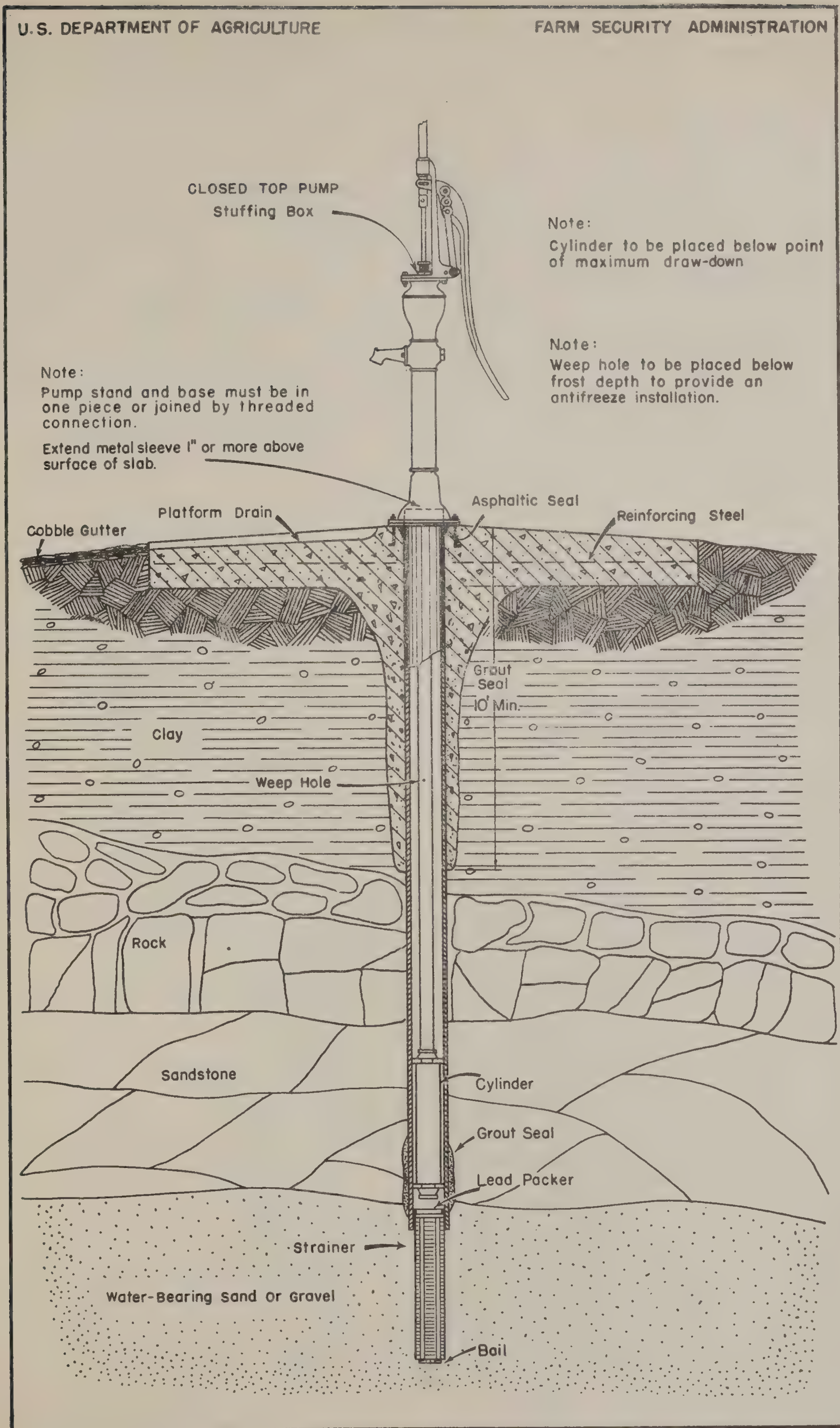


FIGURE 8.— Properly constructed driven well with strainer.

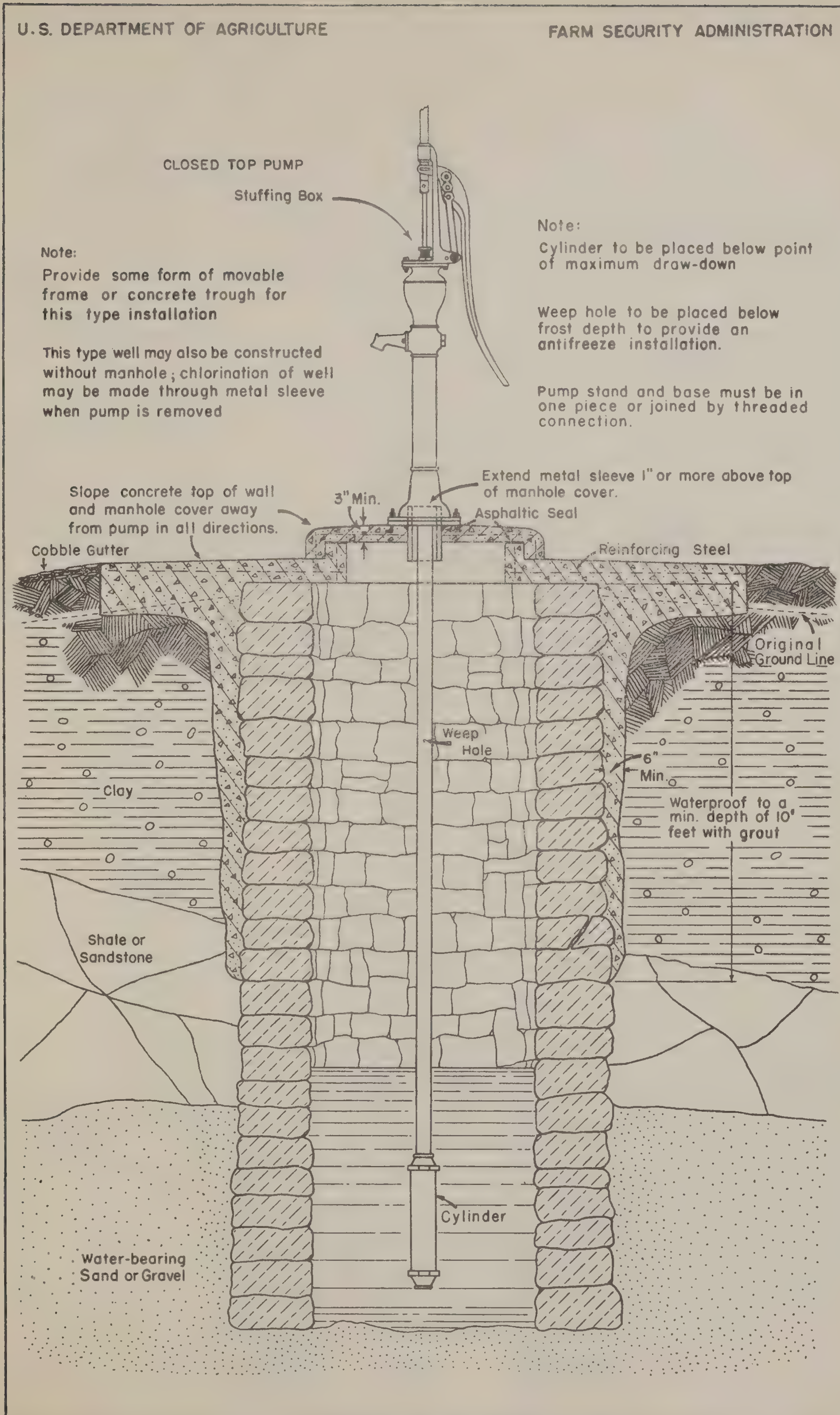


FIGURE 9.— Reconstructed stone-curbed dug well.

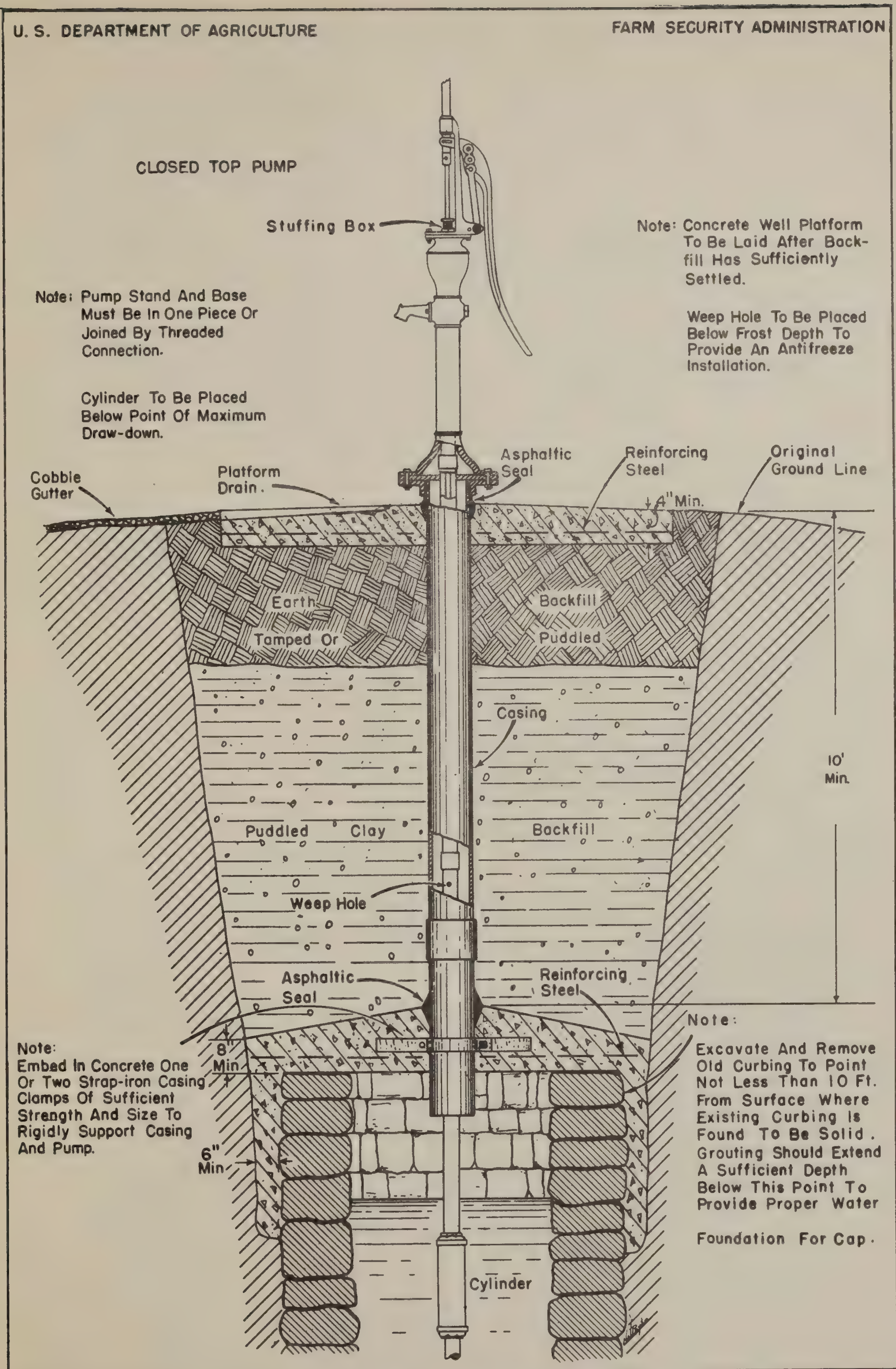


FIGURE 10.— Properly constructed dug well with buried slab.

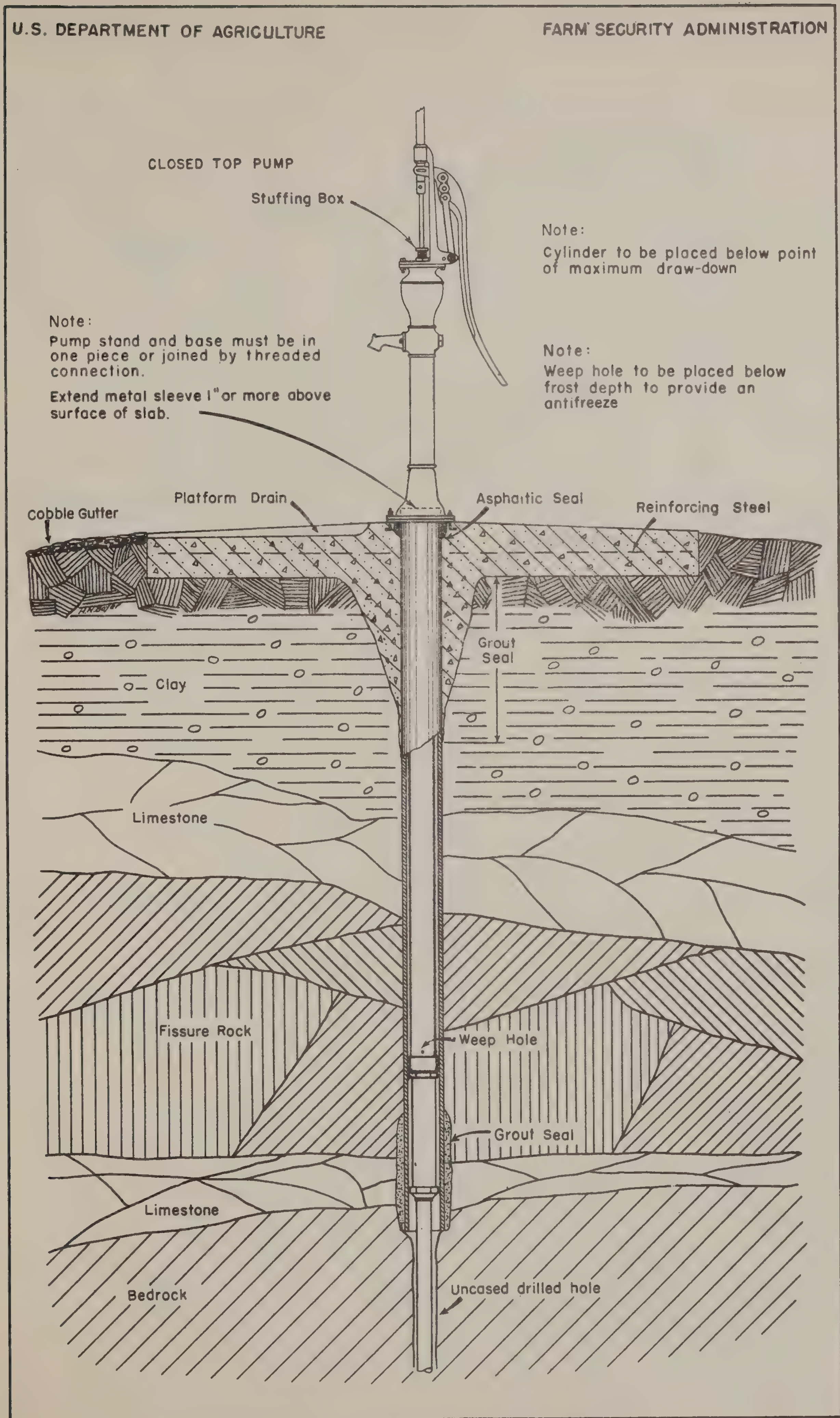


FIGURE 11.— Properly constructed drilled well.

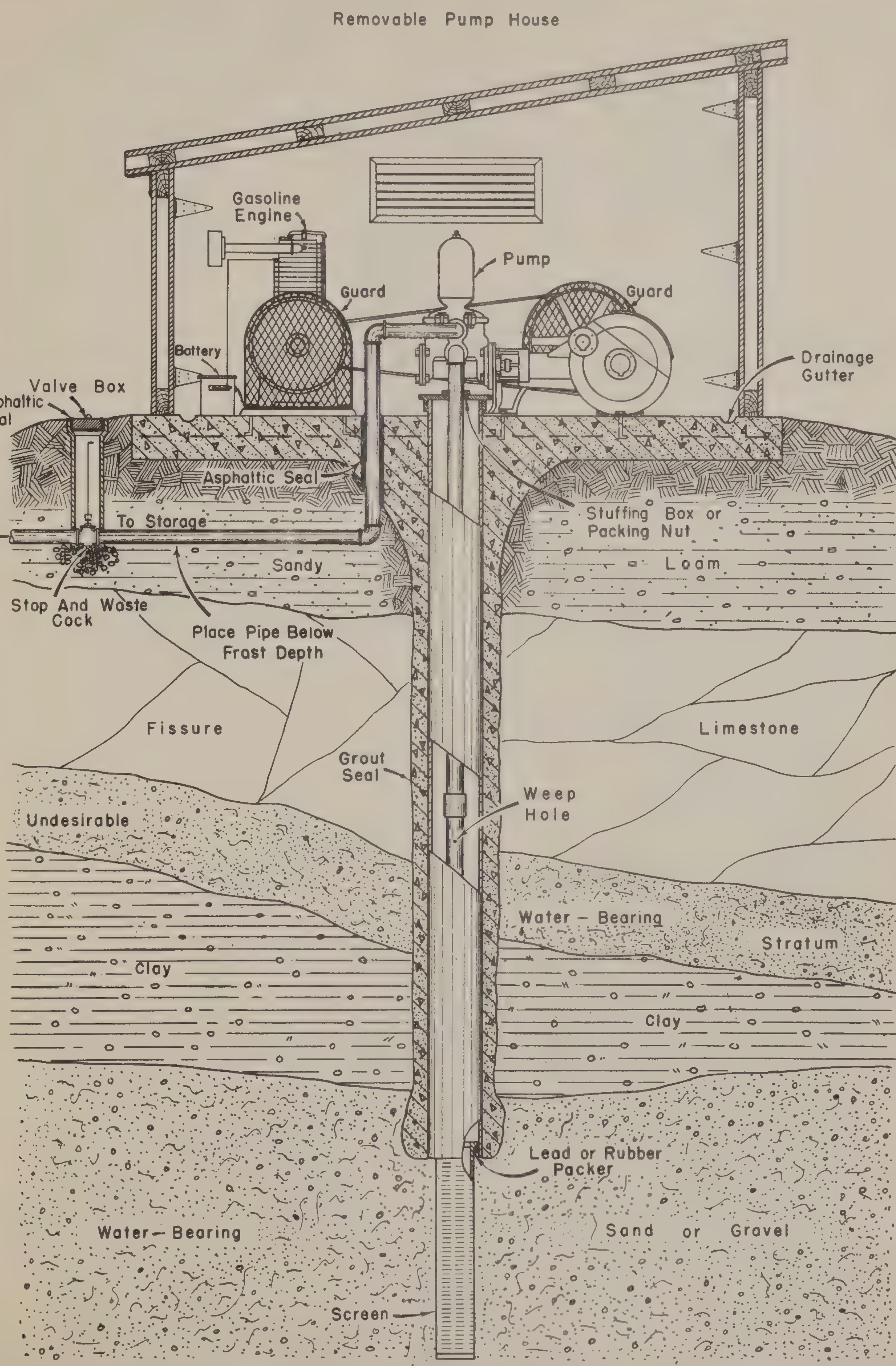


FIGURE 12.— Drilled well showing properly grouted casing.

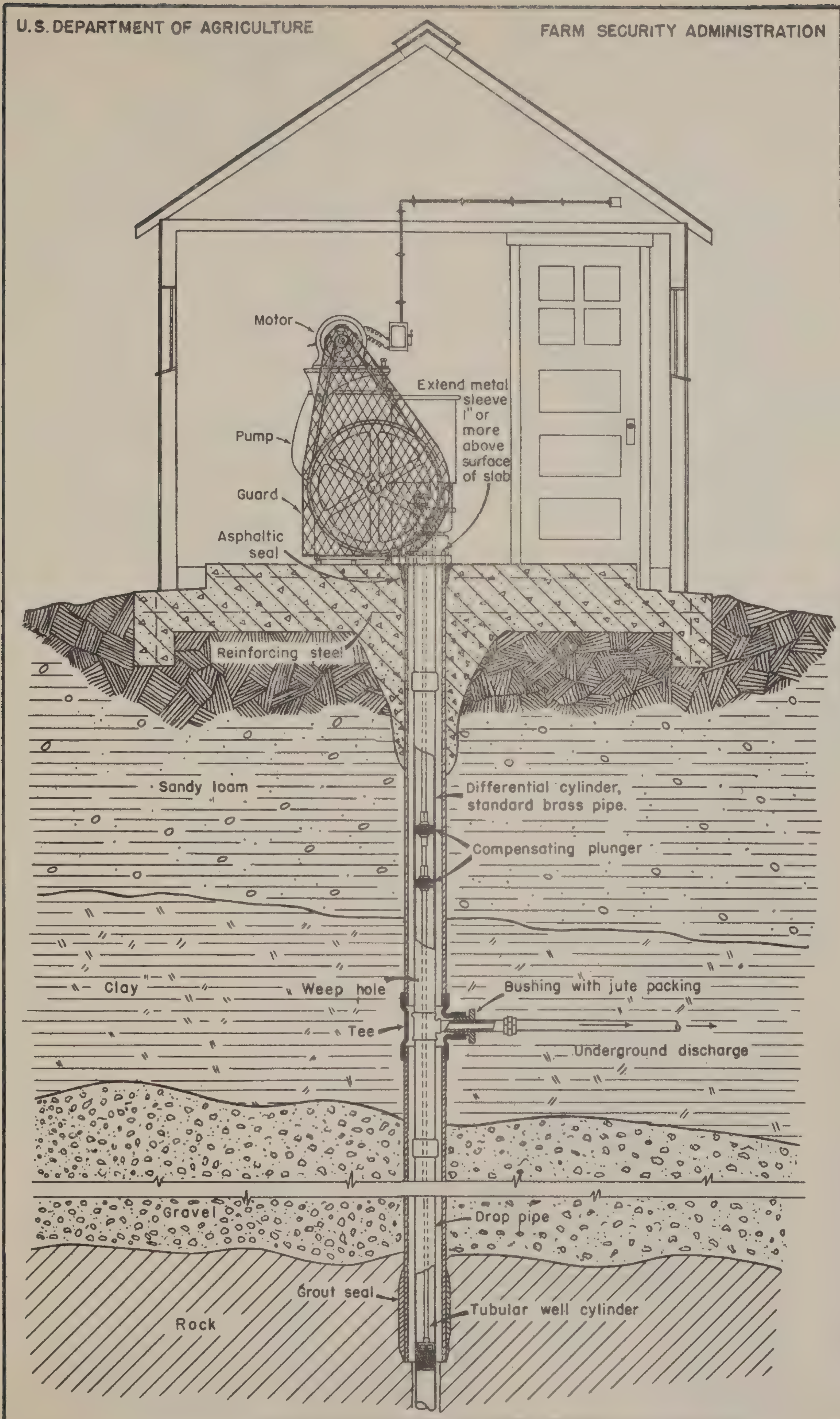


FIGURE 13.— Properly constructed drilled well with underground discharge.

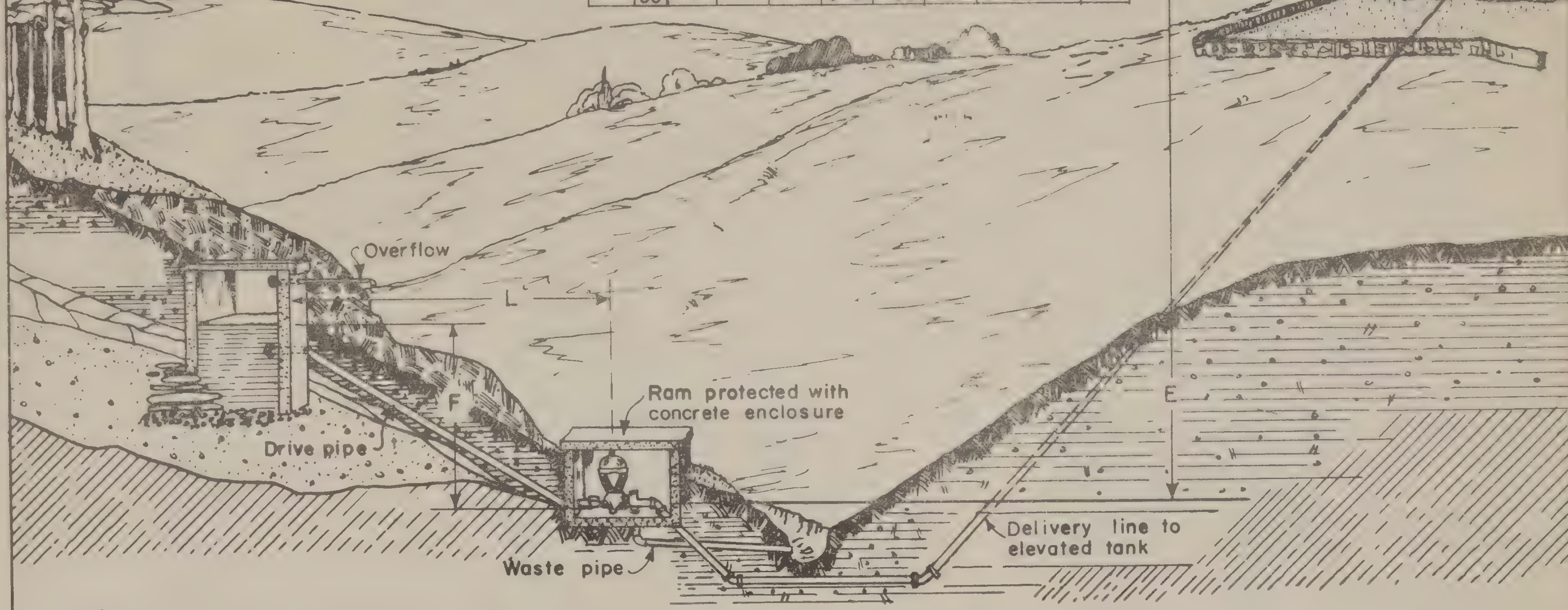
U. S. DEPARTMENT OF AGRICULTURE

FARM SECURITY ADMINISTRATION

TABLE OF APPROXIMATED DELIVERY CAPACITIES

Giving gallons per 24 hr. day delivered for each gallon of spring water flowing per minute at various drive heads and delivery heights

DRIVE HEAD "F" IN FEET	"E" (DELIVERY HEAD IN FEET) 10	20	40	60	80	100	140	180	200
4	432	216	108	64	48	38			
6		324	162	108	72	58	41	32	
8		432	216	144	108	78	55	42	
10		540	270	180	135	108	69	53	48
14			378	252	189	151	108	75	66
20			540	360	270	216	154	120	108
30				540	405	324	231	180	161

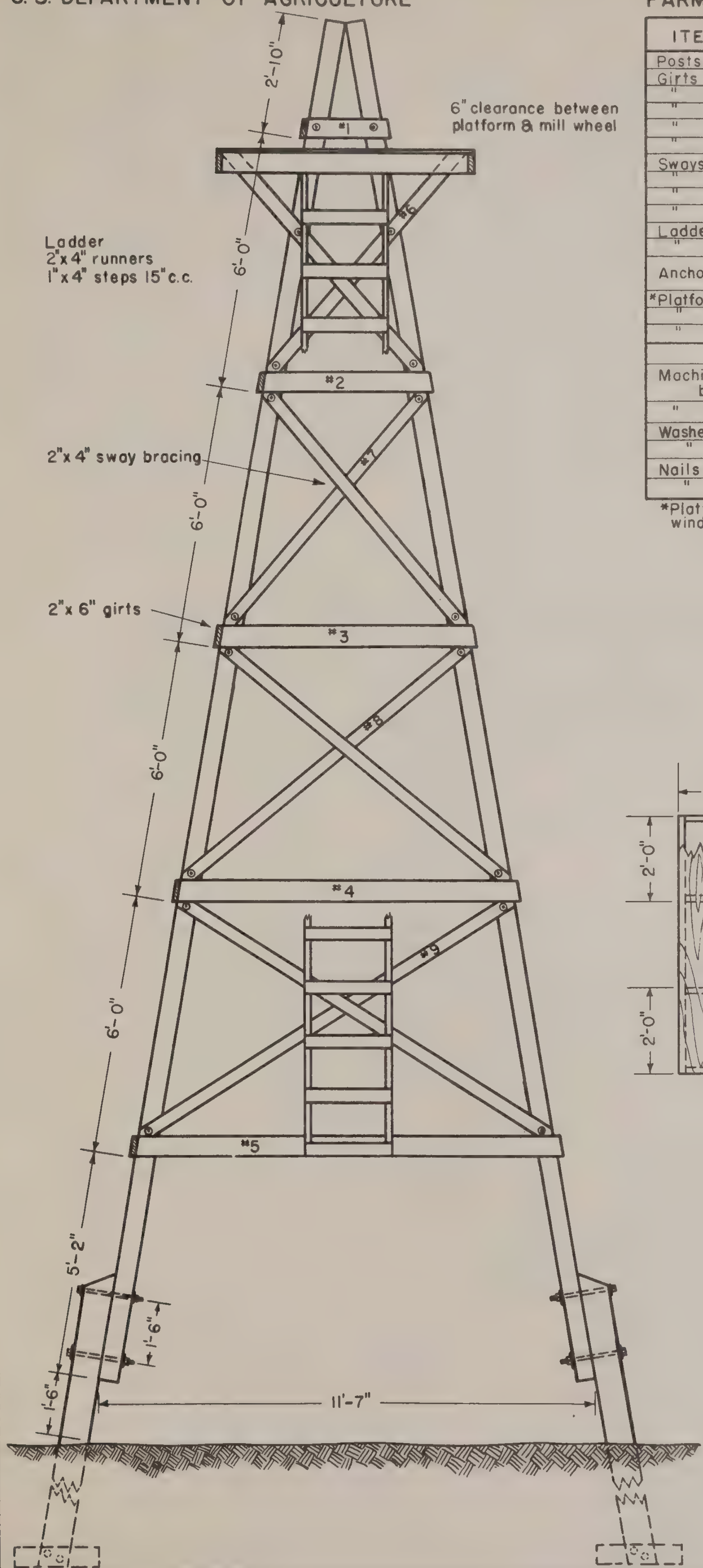


Note:
Length of drive pipe (L) should never be less than 5 nor more than 10 times the head of fall (F) under which ram is placed regardless of delivey head (E).

FIGURE 14.- Proper hydraulic ram installation

U. S. DEPARTMENT OF AGRICULTURE

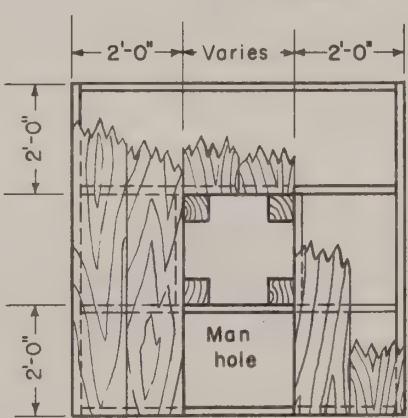
FARM SECURITY ADMINISTRATION



ITEM	PIECES	DIMENSIONS	BOARD FEET
Posts	4	6" x 6" x 32'-0"	384
Girts #1	4	2" x 6" x 2'-0"	8
" #2	4	2" x 6" x 4'-0"	16
" #3	4	2" x 6" x 6'-0"	24
" #4	4	2" x 6" x 8'-0"	32
" #5	4	2" x 6" x 10'-0"	40
Sways #6	4	2" x 4" x 7'-0"	19
" #7	4	2" x 4" x 7'-3"	20
" #8	4	2" x 4" x 8'-9"	24
" #9	4	2" x 4" x 10'-6"	28
Ladder	2	2" x 4" x 23'-0"	31
"	18	1" x 4" x 2'-0"	12
Anchors	4 "	8" dia. x 8'-0" Cedar Posts	
*Platform	4	1" x 12" x 6'-0"	24
"	2	1" x 12" x 2' 0"	4
"	6	2" x 6" x 6'-0"	36
HARDWARE			
Machine bolts	8	¾" x 16"	
" "	72	½" 8½"	
Washers	144	½"	6#
"	160	¾"	18#
Nails		20d	5#
"		10d	3#

*Platform materials vary with size of windmill

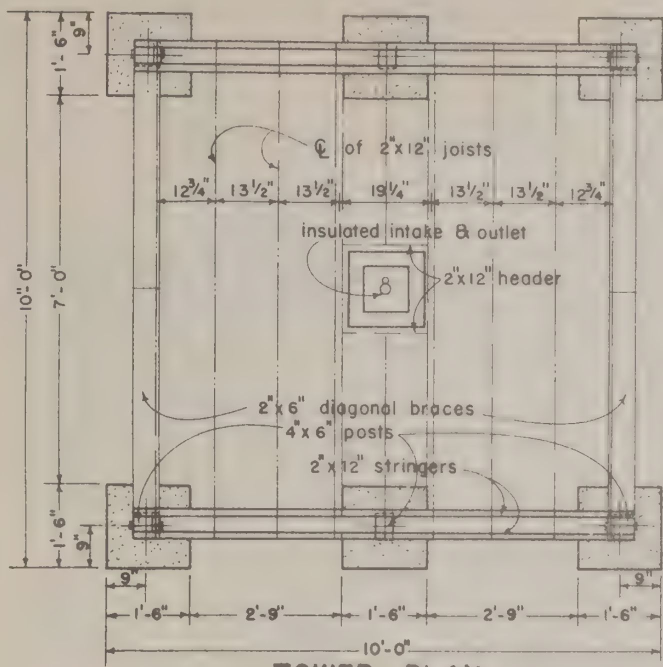
PLATFORM



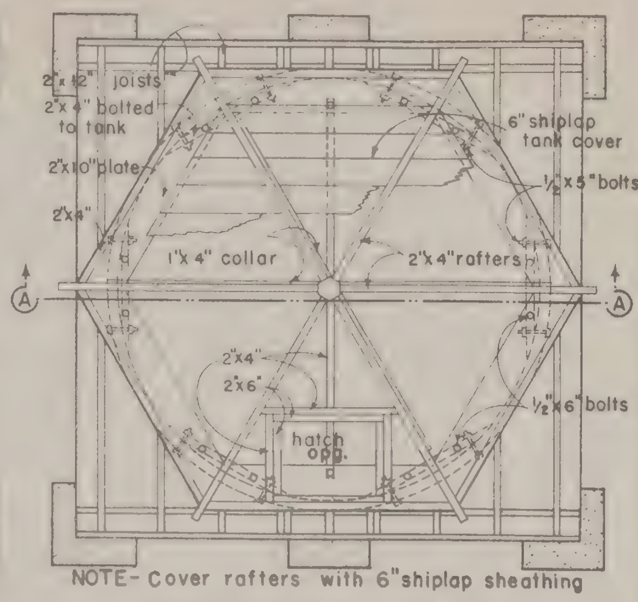
This tower may be used for windmills up to 14 feet in diameter. For larger windmills 8"x 8" corner posts are required.

FIGURE 15.— Wooden windmill tower

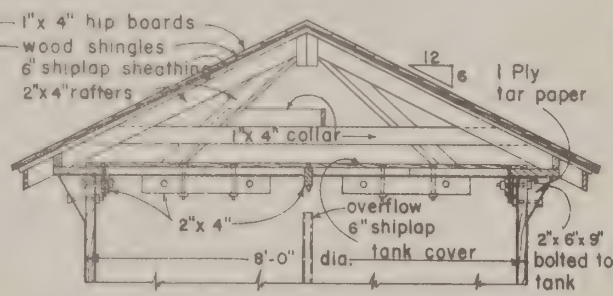
U.S. DEPARTMENT OF AGRICULTURE FARM SECURITY ADMINISTRATION



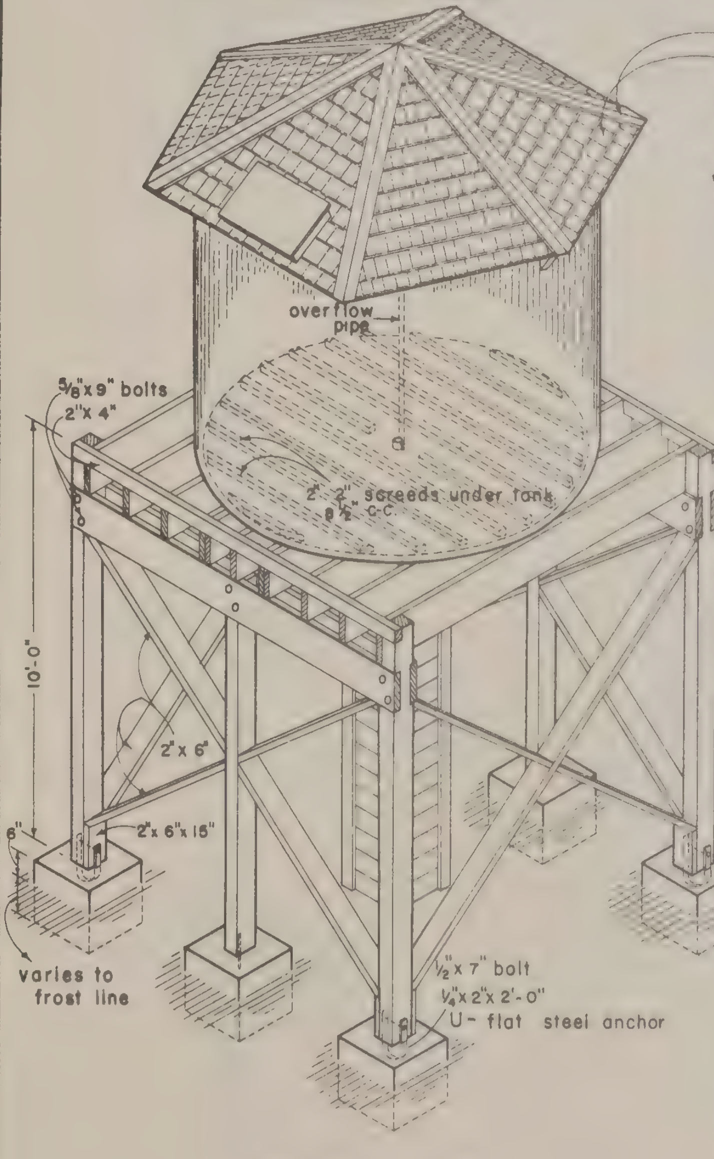
TOWER PLAN



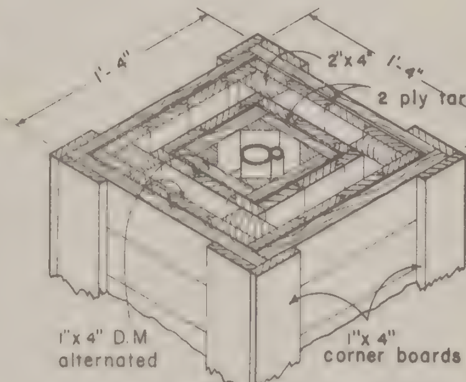
ROOF FRAMING PLAN



ROOF SECTION AA



GENERAL VIEW



SECTION OF INSULATED PIPES

BILL OF MATERIALS				
QUAN	UNIT	SIZE	USE	GRADE & MATERIAL
6	Pieces	4 x 6 x 10-0"	Columns	No. 1 S4S Fir or Y.P.
7	"	2 x 12 x 18-0	Joists, Stringers	" " "
2	"	2 x 12 x 10-0	"	" " "
9	"	2 x 6 x 12-0	Cross Bracing	" " "
1	"	2 x 4 x 8-0	"	" " "
7	"	2 x 2 x 8-0	Screeds	" " "
3	"	2 x 2 x 6-0	"	" " "
			ROOF, COVER	
4	"	2 x 4 x 14-0	Rafters, Bracing	" " "
9	"	2 x 4 x 6-0	"	" " "
1	"	2 x 6 x 8-0	"	" " "
3	"	2 x 10 x 14-0	Plate	" " "
48	"	6 x 6-0	Sheathing	" Shiplap "
7	"	6 x 8-0	"	" " "
7	"	1 x 4 x 12-0	Hips, Collars	No. 1 S4S Fir or Y.P.
4	Bundles	16"	Roofing	Cedar Shingles
8	"	1 x 4 x 10-0	Corner Boards	No. 1 S4S Fir or Y.P.
42	"	1 x 4 x 8-0	Side Covering	Dressed & Matched
28		1 x 4 x 10-0	"	" "
1	Roll	15 lb	Insulation	Tar Paper
14	Each	1/2 x 5 ϕ	Roof	Machine Bolts
18	"	1/2 x 6 ϕ	Roof	" "
12	"	5/8 x 9 ϕ	Stringers	" "
4	"	1/2 x 7 ϕ	Anchors	" "
4	Pieces	1/4 x 2 x 2-0	U-Anchors	Flat Steel
12	LBS.	16 d	Bracing	Box Nail bright
12	"	8 d	Sheathing etc.	" " "
7	"	5 d	Shingling	Shingle Nails

NOTE- No tank materials listed; order sand, gravel, cement as needed.

FIGURE 16.
Tank tower 2600 gal. capacity

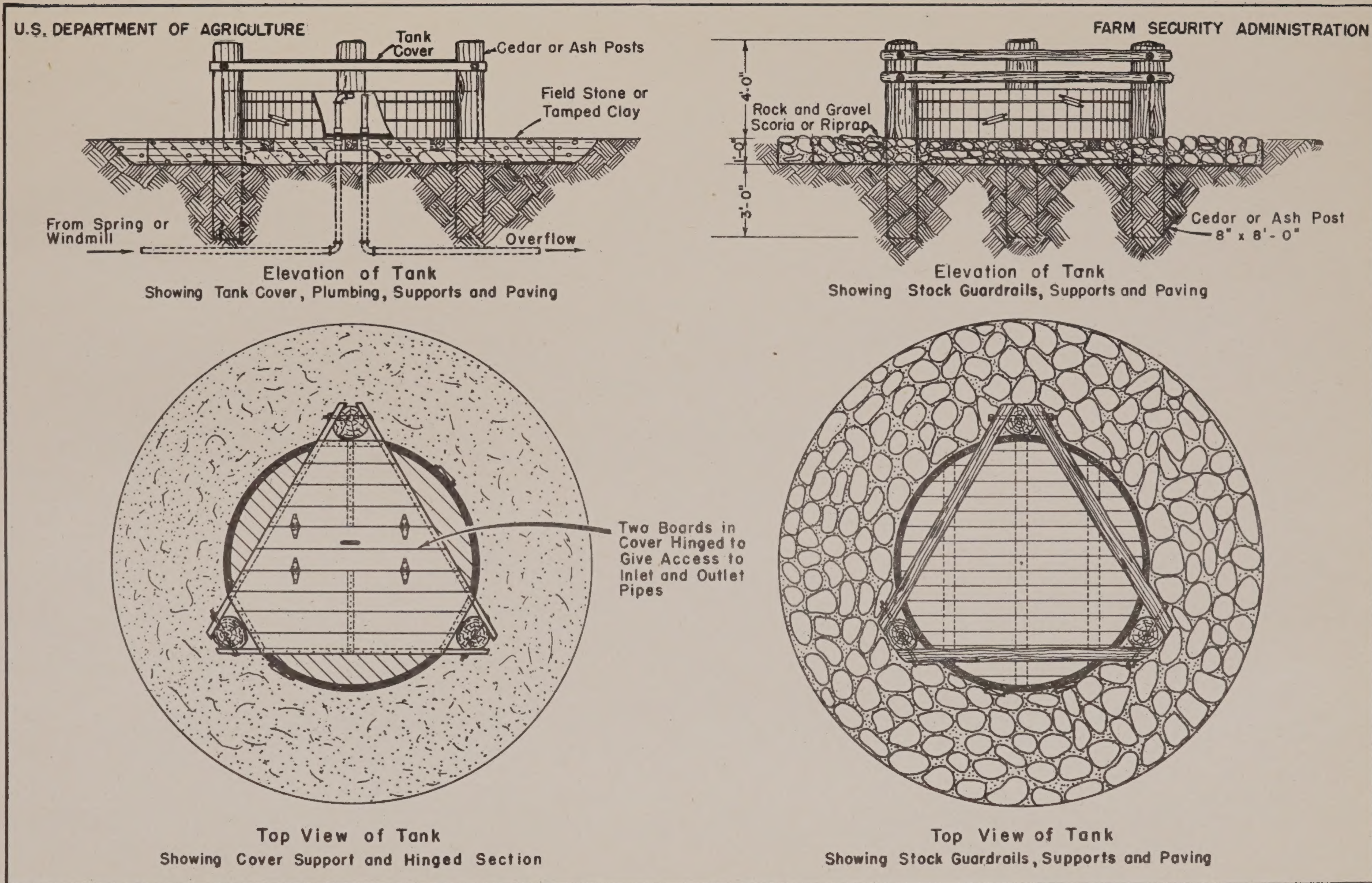


FIGURE 17.— Satisfactory designs for cattle watering tanks.